

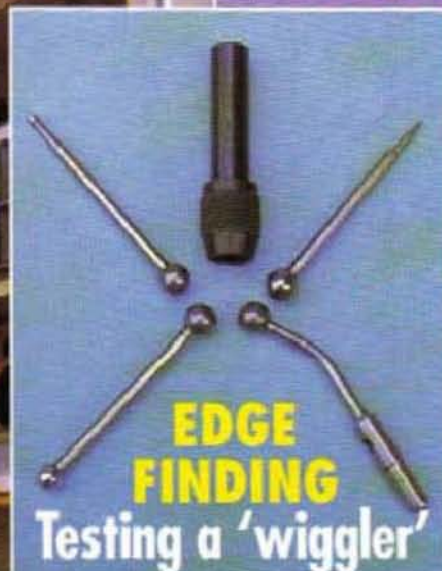
# MODEL ENGINEERS' WORKSHOP

THE NEW, PRACTICAL HOBBY MAGAZINE

**FREE  
PLAN!**  
For a simple lathe

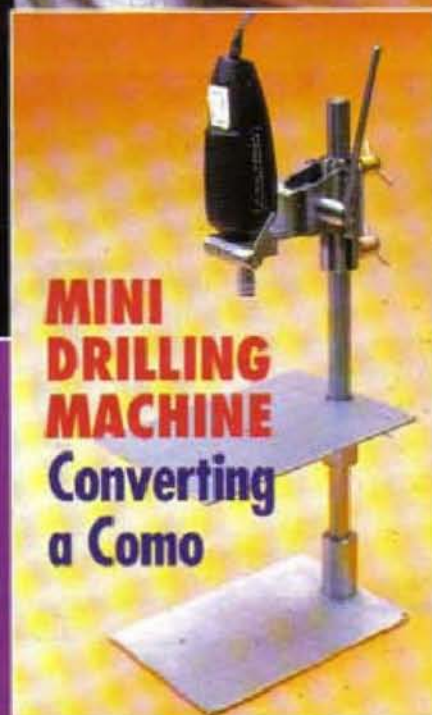


**HOME-MADE  
COLLETS**  
For accurate  
workholding



**EDGE  
FINDING**  
Testing a 'wiggler'

**VERNIER  
VERSATILITY**  
Ahead on points!



**MINI  
DRILLING  
MACHINE**  
Converting  
a Como



**TAPER  
TURNING**  
On the  
Toyo  
ML 210  
Lathe



**DRILLING JIGS**

Save spoilt castings



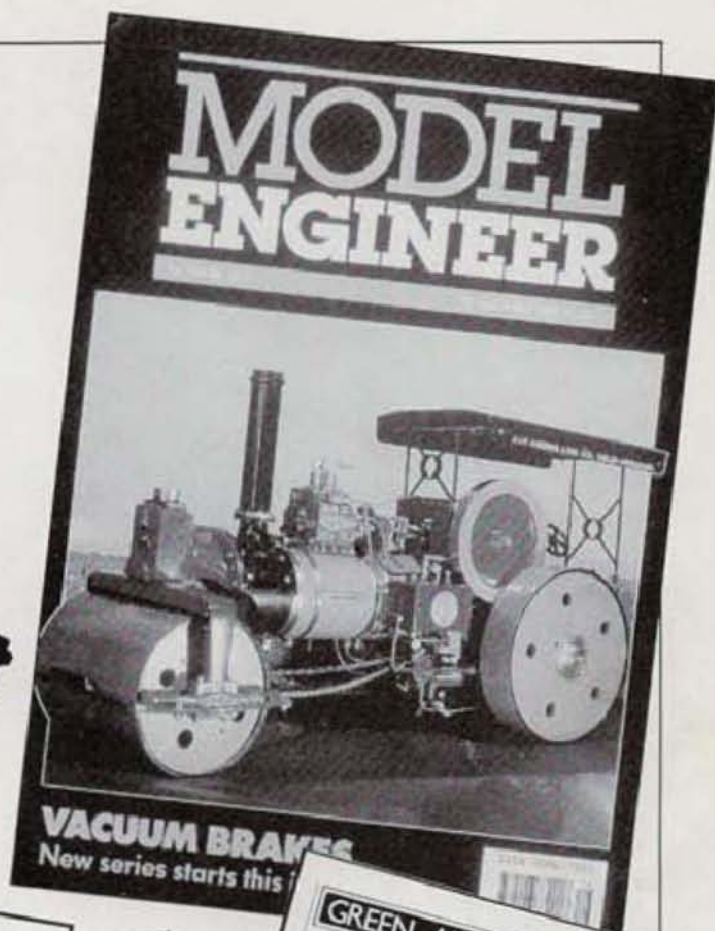
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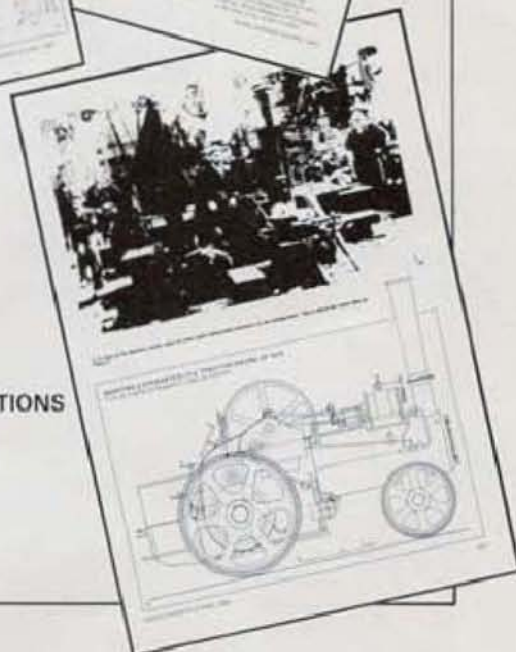




**SOMETHING  
TO LOOK  
FORWARD  
TO...**  
*...every fortnight*



There's something to anticipate twice every month in fascinating Model Engineer magazine! Whether your interests lie in live steam locomotive models, traction engines, internal combustion motors or stationary engines, world famous M.E. will inspire, instruct, advise and encourage. Model Engineer is published on the first and third Fridays each month and costs just £1.40 from all good newsagents; alternatively, you may care to ensure your regular copies through an annual subscription – a mere £33.60 for UK readers (overseas rates and airmail details on request).



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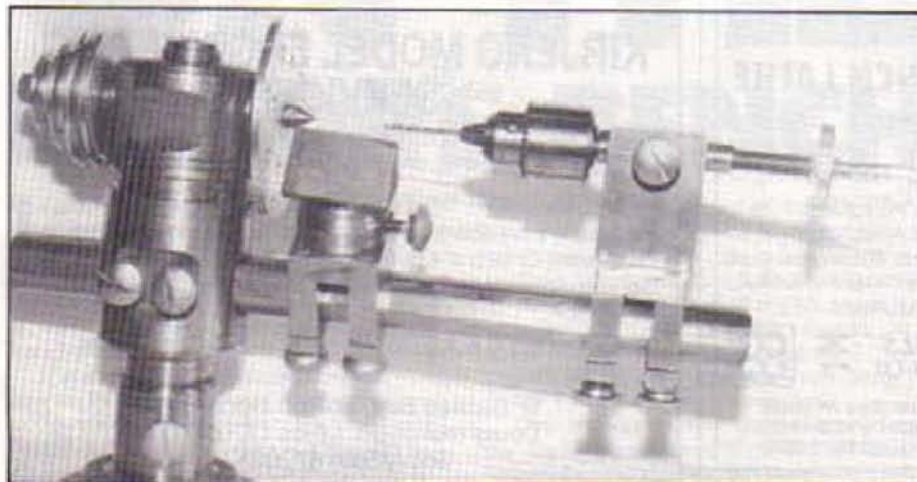
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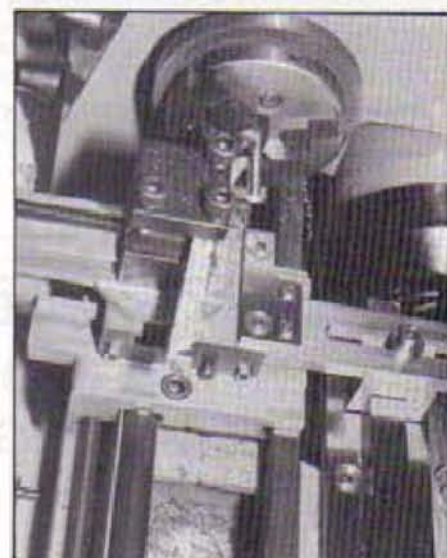
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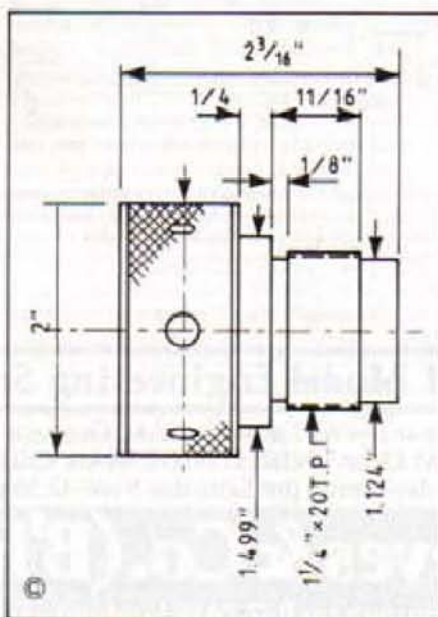
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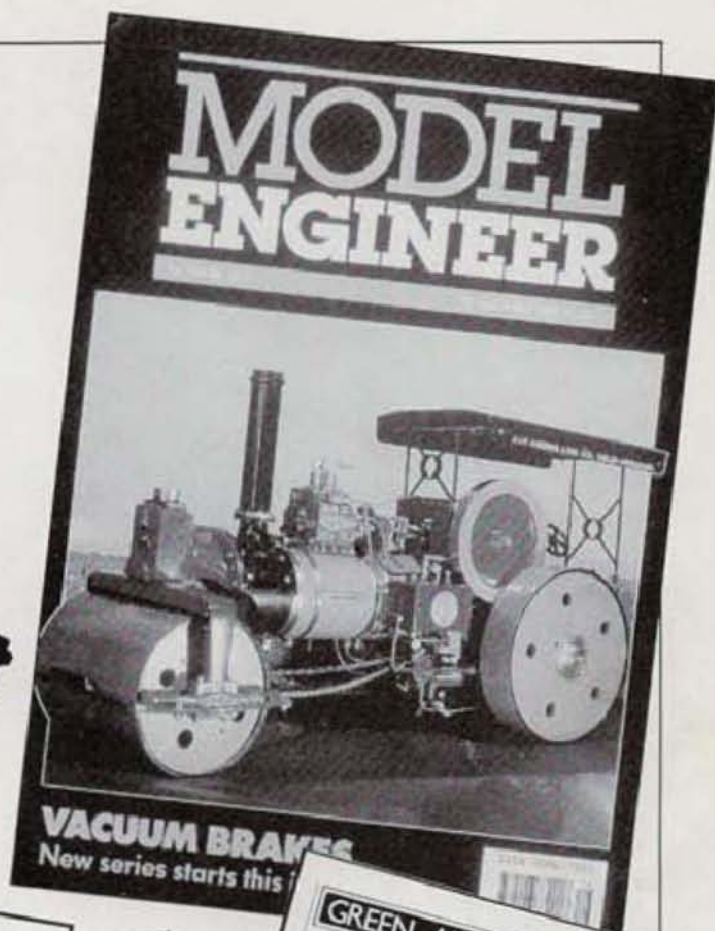
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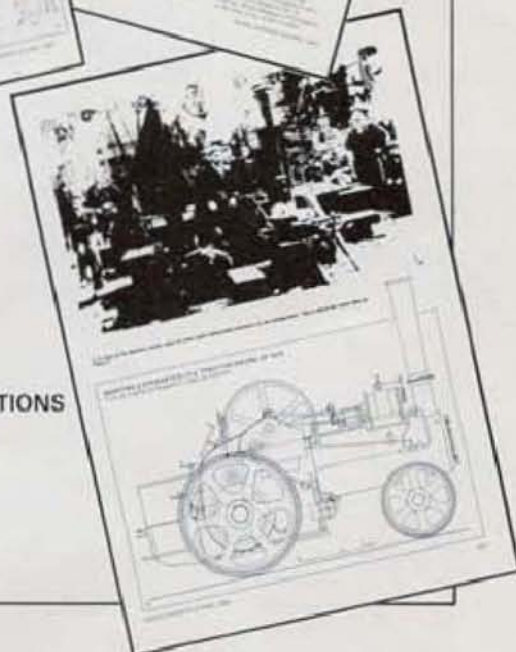
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*Harold Hall*

# ON THE EDITOR'S BENCH

**I**t is with some considerable surprise and no less pleasure that I find myself writing this, my first editorial. After 30 years working for the same firm the possibility of a major change in occupation is one that seemed a remote possibility but here I am!

It is also with some trepidation that I take on this task in view of the magazine's undoubted success under the editorship of Stan Bray. Stan as its originator is going to be a hard act to follow and with such a successful magazine it would be foolish of me to come in with major ideas for change - your letters bear this out, so it is intended to be business as usual with just a few minor improvements.

So thanks once again, Stan, for your efforts in the past; they are certainly ones which you can be proud of, and I am pleased to know you are still going to be around to advise from time to time.

Well, I feel this is the time, and the only time, to say a little about myself. Starting with my working life, I first went to work for an electrical switchgear manufacturer with the intention of becoming a qualified electrical engineer, but, due to my apparent ability whilst starting my apprenticeship working in the machine shop, I found myself spending over three years of my training in the jig and tool and production methods office. As a result I finished up with a largely mechanical apprenticeship, but with electrical qualifications which I had gained during six years of part-time technical college attendance.

After a few years I moved as an electrical engineer to a firm producing high power and, increasingly over the years, more and more complex electrical variable speed drive systems.

Here I stayed for 30 years. My early days in the jig and tool office stood me in good stead, often putting me one up on my purely electrical and latterly electronic colleagues.

As far as my hobbies are concerned, I purchased my first lathe at the age of 15 but it was very small and I do not remember using it as it had no chuck. I do remember all the slides were made using round rods - does any reader have any idea what make it may have been or maybe still have a machine like this? At 16 I

purchased a second-hand Myford ML4 on which I made probably my biggest totally mechanical project to date, a Cowells of Watford drilling machine, still very much in use today. By the age of 19 the ML4 was replaced by a new ML7 which I kept till about five years ago when I had the opportunity to purchase a very run-down Super 7 which I totally overhauled.

Over the years I have largely devoted my workshop activities to making extras to improve its capabilities, but have also made two diversions into model engineering which have been reasonably successful.

My only other serious hobby is one of high-quality live sound recording which has mostly been of Salvation Army music of which organisation I am a member. I have had recordings broadcast by BBC national radio as well as local stations and some foreign stations also. Otherwise I am very much a jack of all trades and master of none, with photography possibly being my third favourite interest.

Well, I think that is enough about me. I hope you enjoy this issue of *MEW*; I have attempted to offer a range of projects to suit most tastes but I'm sure you'll let me know if you don't agree. Among them is an interesting article on using the centre finder (wiggler) with tests to establish the accuracy of the various methods of using it. (I have recently seen various conflicting suggestions as to how it should be used - can any reader throw any light onto how long this device has been around? I can only recollect having seen it in catalogues in recent years, so is it new or have I just been going around with my eyes closed?)

There have been numerous comments from readers regarding the lack of any form of issue number for *Model Engineers' Workshop* and, as a result, they have found difficulty in establishing whether they had a complete set or not. One Australian reader, for example was additionally confused purchasing his winter copy in the middle of summer! As a result, from this issue *MEW* will carry an issue number, this one being number seven. For those still unsure with regard to past issues, they have been:

Summer 1990; Autumn 1990; Winter 1990/91; April/May 1991; June/July 1991; August/September 1991.

## IN OUR NEXT ISSUE!

Coming up in the December/January issue will be:-



**HAND VERNIER TO HEIGHT GAUGE CONVERSION.**

**A NOVEL TOOLMAKER'S HAMMER.**

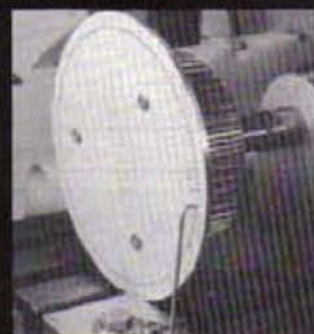
**COLLETS FOR HOLDING THE THINNER ITEMS.**



**A FABRICATED FOUR WAY TOOL POST FOR THOSE WITHOUT MILLING FACILITIES.**

**ANOTHER ATTACHMENT FOR THE TOYO LATHE, THE SECOND IN A SERIES**

**AN INTERESTING APPROACH TO PRODUCING DIVIDING PLATES BY COMPUTER.**



**IMPROVING SURFACE FINISH BY OVERCOMING LATHE VIBRATIONS.**

**AN ENCOURAGEMENT TO THOSE WITH LIMITED SPACE, WE LOOK AT AN INTERESTING INDOOR WORKSHOP.**

**MODERN TECHNOLOGY IN THE FORM OF AN ELECTRONIC DIGITAL READOUT, AN ALL-EMBRACING PROJECT.**



**AND MUCH MORE**  
Dec/Jan issue on sale November 8th  
Contents may be changed





In this article Derek Winks of Kingsbury, London has produced a very nice design for a taper attachment for his Toyo 210 Lathe. It has the added advantage over many designs of including a micrometer adjustment. Whilst intended for the Toyo Lathe there should be no problem in adapting this for other makes

Photo 1. The attachment before mounting.

# TAPERS ON A TOYO

The Toyo ML210 lathe is not provided with a set-over tailstock, so the only means of turning tapers is by the use of the top-slide. This is limited to a length of 45mm. Also, as the smallest angular division is 5 degrees, setting a slow taper is very much a matter of guesswork. This attachment was designed to provide a means of setting up a taper accurately at first go, without need to resort to tedious cut-and-try methods.

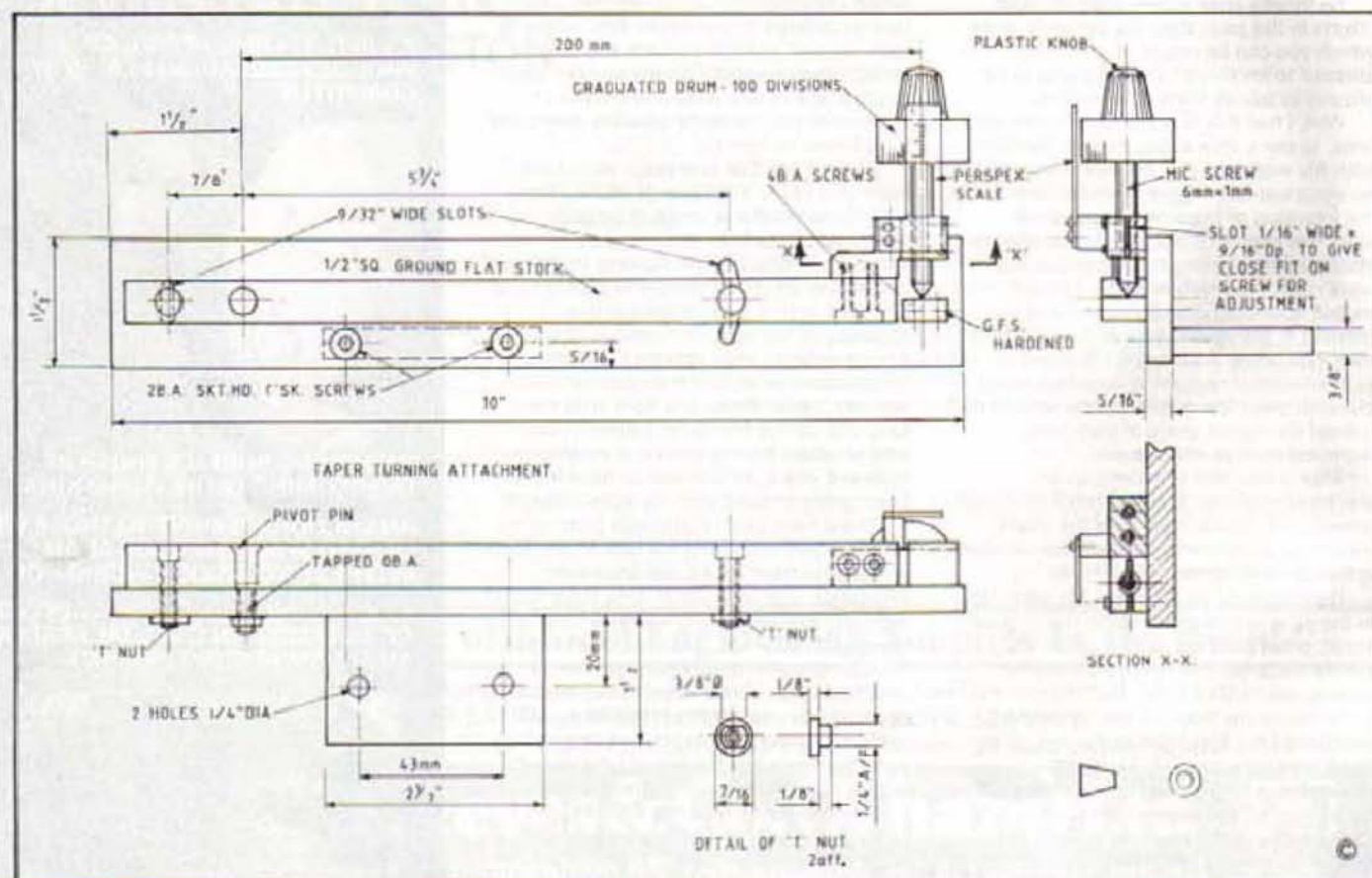
It takes the usual form of a guide bar mounted behind the lathe bed which controls the movement of the cross-slide, which has of course been disconnected from its usual feed-screw.

The construction can be seen in Photos

1 & 2. The base is a length of flat steel 1.5in. x 1in. x 10in. long. A bracket projecting from the underside of this can be bolted to a machined surface on the rear of the lathe bed. The upper side carries the guide bar which is a length of 1in. square ground flat stock. This must of course be straight. I checked the bar against a good quality straight-edge, selecting the best portion. The bar is pivoted 1in. from its left-hand end on a 1in. dia. pin which must be a close fit in its reamed hole. Two Allen screws with their heads recessed into the guide bar go through slots in the base and serve to clamp the bar firmly to the base after the angle has been set.

## Geometry of the device

The diagram illustrates the geometry of the device - with the angles exaggerated for clarity. The line OA represents the centre line of the guide bar with the pivot at O. The line AC is the centre line of the micrometer screw which has a pitch of 1mm. AC is at right angles to OA. OC is a line parallel to the lathe axis. The point of the micrometer screw bears on a steel block, the face of which falls on the line OC. The distance OA = 200mm. The distance AB represents the travel of the cross-slide as the saddle is transversed from B to O. H is the half-angle of the taper to be turned. S is the setting of the micrometer, which is





set to zero with the guide bar parallel to the lathe axis. As the triangles OAC and OAB are similar,

$$\frac{S}{200} = \frac{AB}{OB} = \tan H$$

Thus if the taper to be produced is specified by the included angle A, then the setting required on the micrometer is

$$S = 200 \tan(A/2) \text{ mm.}$$

If the taper required is specified as inches per foot on diameter, divide by 12 to convert to inches per inch. As this is a ratio it is independent of units. Let this = R, then

$$R = \frac{2 \times AB}{OB} = \frac{2S}{200} = \frac{S}{100}$$

thus the setting required  $S = 100R \text{ mm.}$

### The Micrometer setting device

The details of the micrometer setter can be seen in **Photo 3**. The screw is 6mm dia. x 1mm pitch which is a standard size so that a tap for the nut is easily available. The screw was made from 1/2 in. free-cutting silver steel, obtainable from Chronos. One end of a 60mm length was turned to a 60 degree point, the other end centre-drilled, the piece mounted between the centres with a female centre in the tailstock and the portion to be threaded 40mm long reduced to 6mm dia. and a screwcut using the screwcutting attachment also added to this lathe. (For those without this facility, an M6 die should give adequate results. Ed). The nut should be made first so that a good fit can be obtained, taking care to get a good finish on the thread. It is best to use the top-slide, set over to half the thread angle so that the tool cuts on one side only.

The micrometer dial is about 28mm dia.

with 100 divisions. These were marked using the division plate set up in a larger lathe, with a pointed tool set sideways in the toolpost using the top slide index for controlling the length of the lines. Each 5th and 10th line was extended in the usual way. Each 10th division was marked 0.1 to 0.9 with number stamps using a simple jig as seen in **Photo 5** to place the stamp accurately. A grub screw was fitted for securing the drum to the screw.

The nut portion of the micrometer was cut from 1/2 in. flat mild steel. After tapping the thread the piece was slotted and two 4BA adjusting screws fitted as shown so that any shake of the micrometer screw could be eliminated. The nut is fixed to the guide bar with two 4BA screws. The micrometer screw must be at right angles to the bar. A Perspex scale graduated in millimetres is attached to the nut so that it just clears the micrometer dial; it indicates

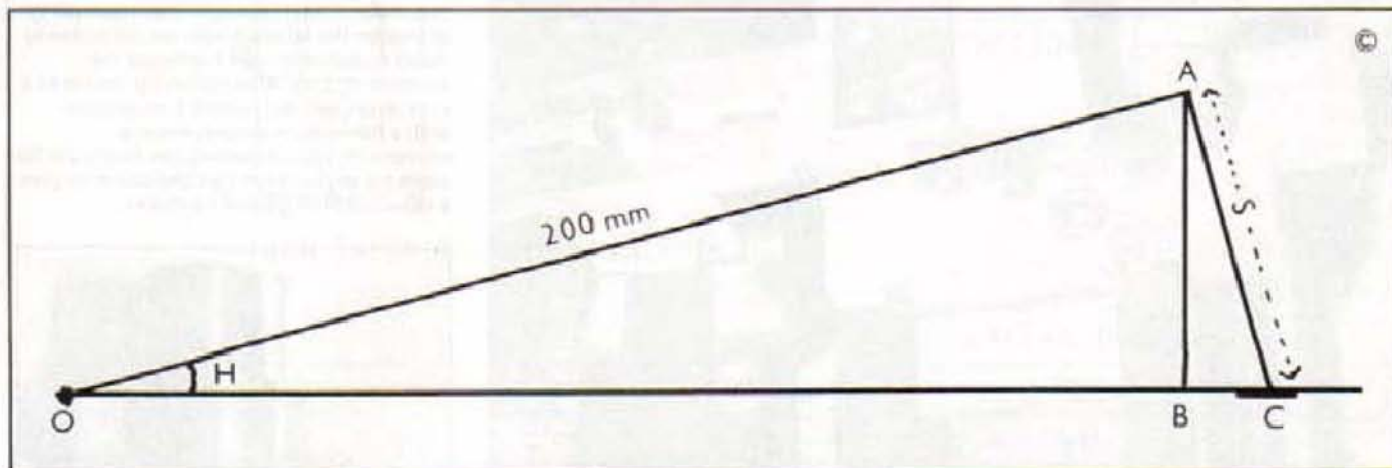
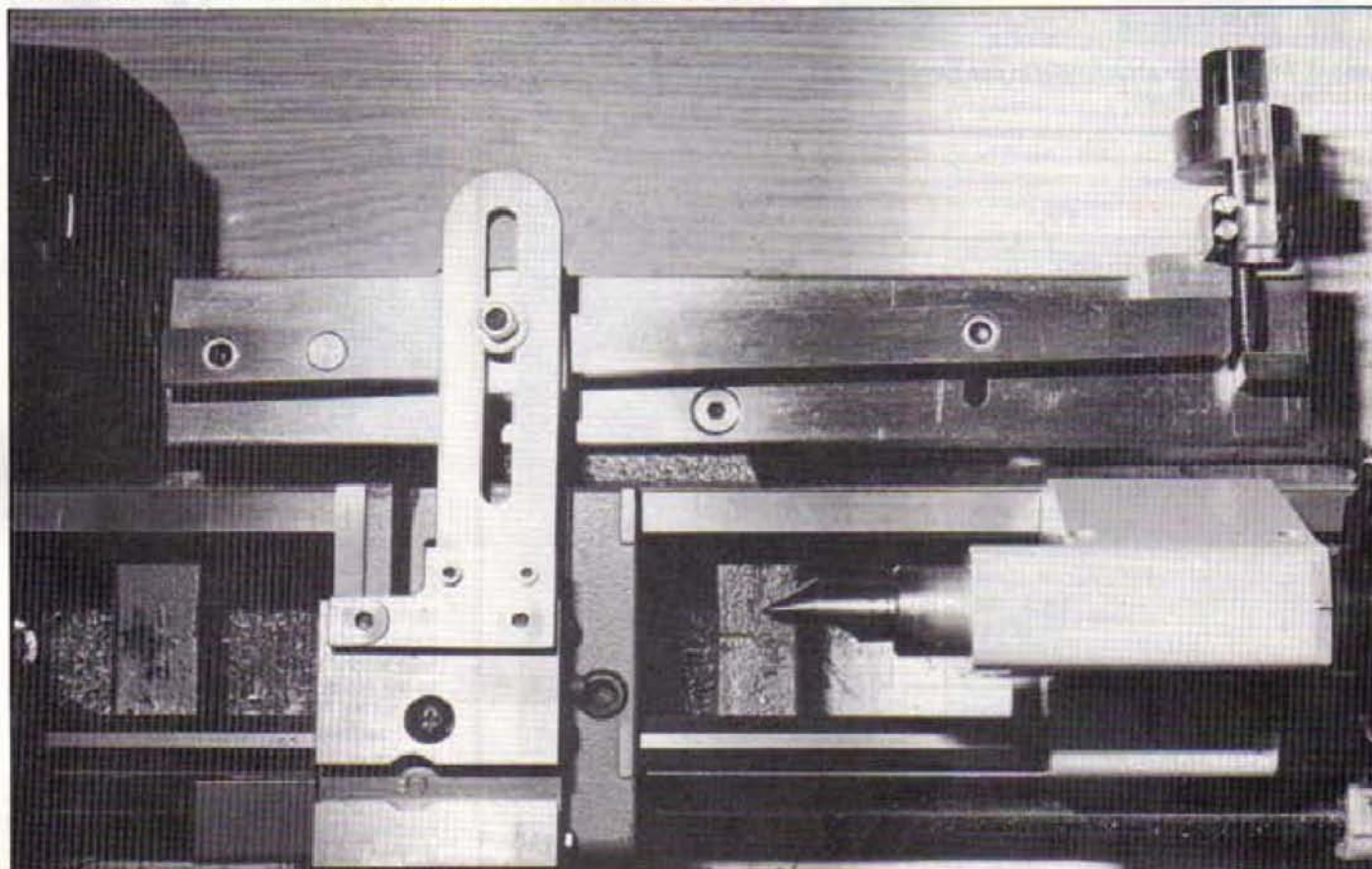
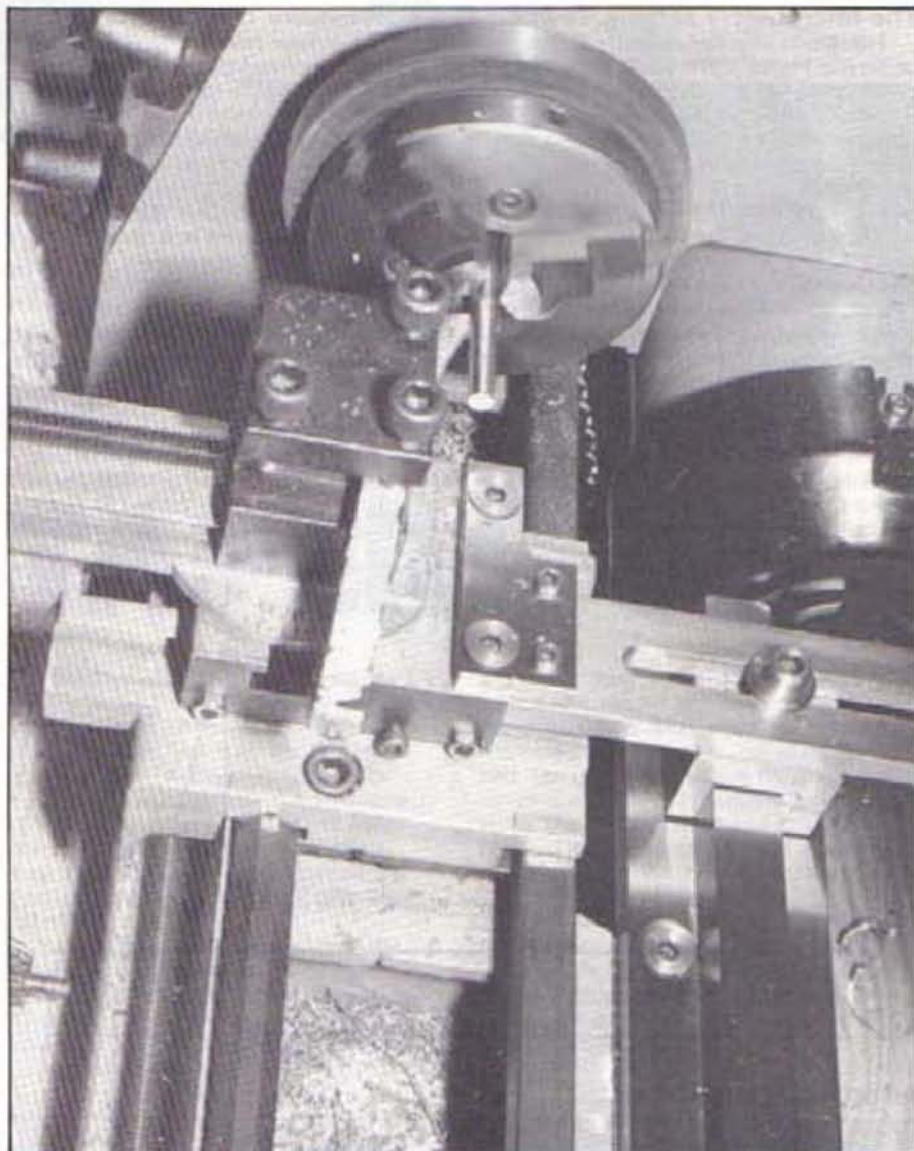


Photo 2. The attachment fitted to the author's Toyo ML 210, ready for use.



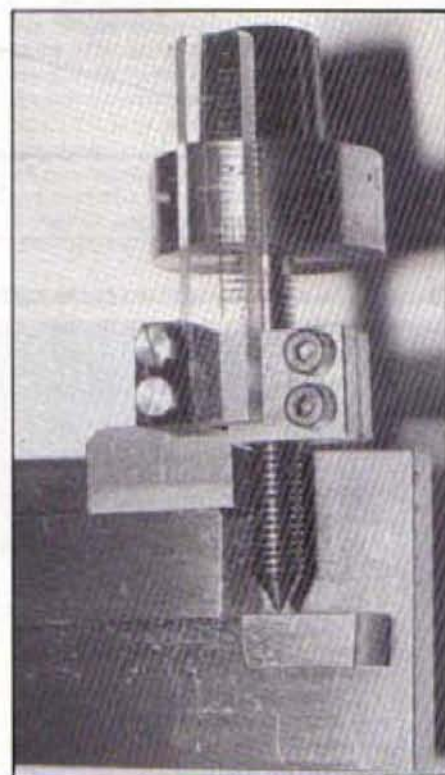




the number of full turns of the screw, and carries the index line for the dial graduations. The graduation lines on the dial and scale were filled with black paint to improve legibility. The knob is a plastic collet-type knob 15mm dia. obtainable from electronic component suppliers.

The distance between the centre lines of the pivot and the micrometer screw must be as near as possible 200mm. The method of achieving this will depend on the equipment available; I used the table feed screw of the Emco miller as the measuring device.

The steel block of which the point of the micrometer screw bears was made from a scrap of 1in. ground flat stock; it was attached to the base with 4BA Allen screws in a position so that the face is on the centre line of the base bar. The block was hardened by heating to redness and quenching in oil in the usual way. After hardening, the face was polished flat on a fine water stone. I thought that attempting to harden the whole screw would probably result in distortion so I hardened the extreme tip only. After polishing the tip to a very small radius, I heated it to redness with a flame from an oxypropane microtorch; after removing the flame the tip cools rapidly enough by conduction to give a reasonable degree of hardness.

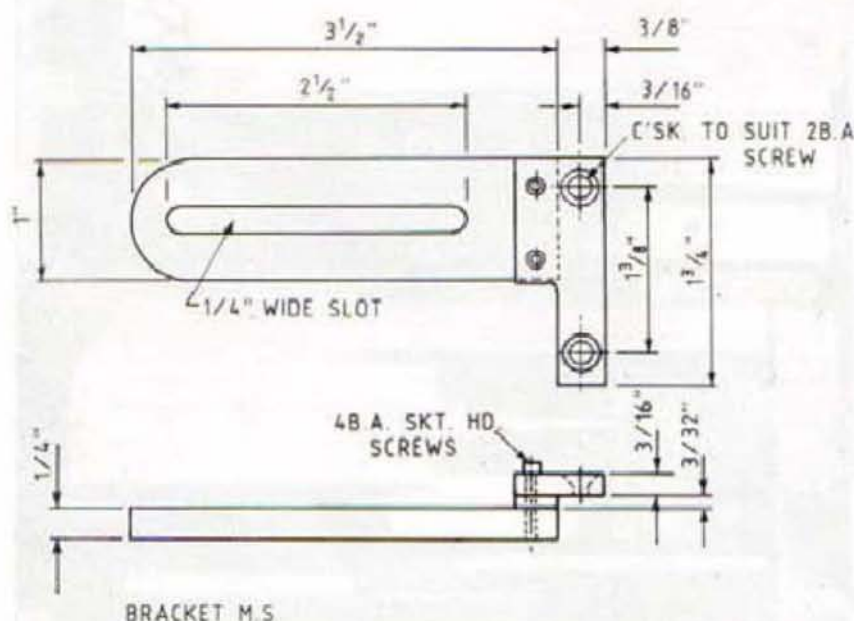


### Guide bar connections

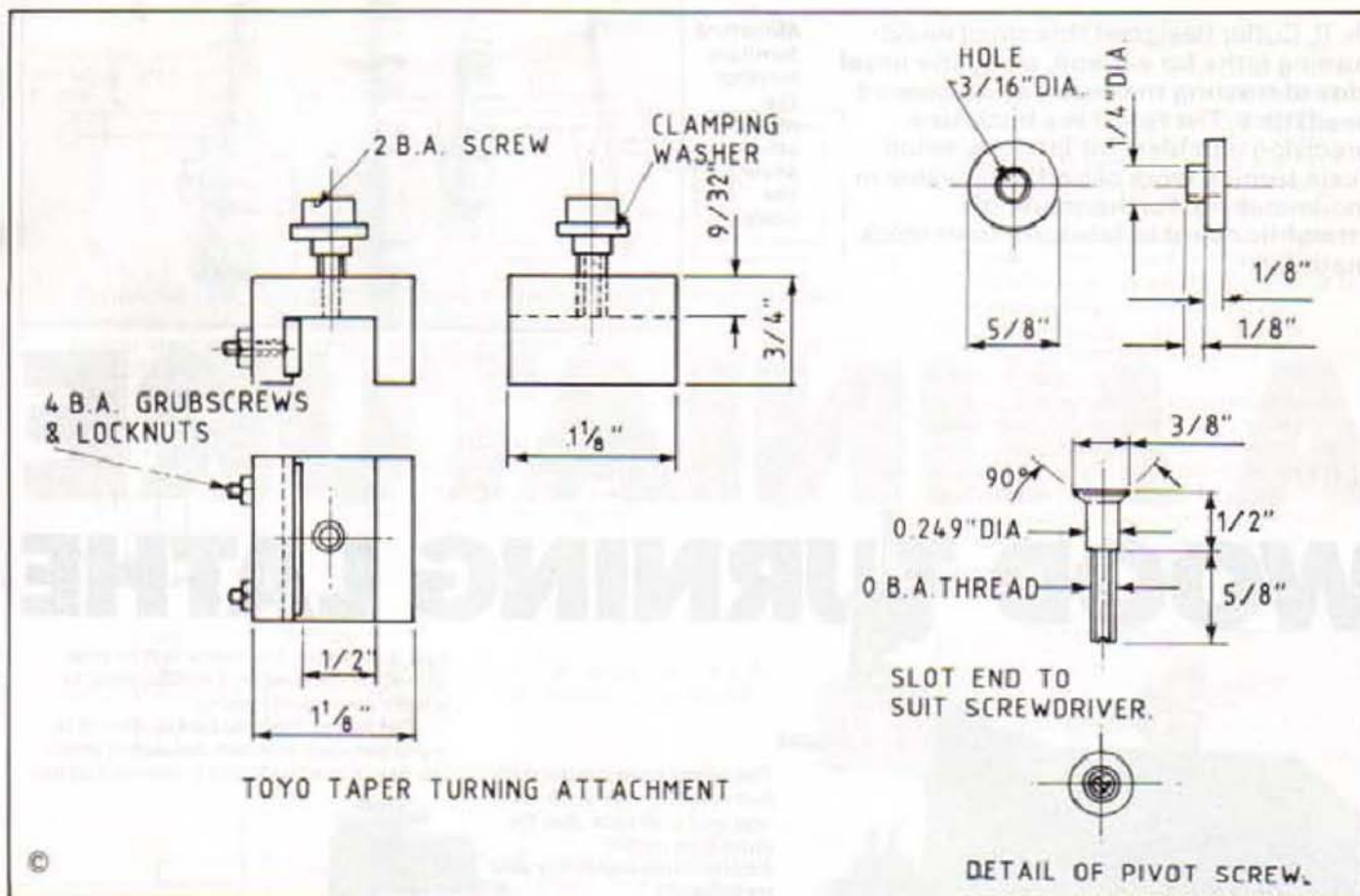
The guide bar is connected to the lathe cross-slide by a slotted bracket as shown. It is necessary to remove the slide from the lathe to drill and tap two 2BA holes for the fixing screws; there is plenty of metal to take these. The rear of the bracket is bolted to the block which slides along the bar guide.

The block is fitted with a gib strip with the usual adjusting screws at the back. There should be a good clearance between the top of the bar and the block to prevent binding. The gib strip should be adjusted so that the block slides freely along the bar;

Above, Photo 4. The attachment in use turning a taper pin. Right, Photo 3, the micrometer adjustment.







any tightness here could cause the saddle to twist on the lathe bed.

### Cross-slide disconnection

The cross-slide feed screw must of course be disconnected before the attachment can be used. This is most easily done by removing the handwheel so that the screw can slide freely through its bearing; this is done by using a thin-walled spanner, then unscrewing the wheel. This also gives clearance to fit the top-slide at right angles to the lathe axis to act as temporary cross-slide.

### Setting the device

The micrometer must be set to zero before the device can be used. The guide bar was set parallel to the lathe as nearly as possible by eye, then clamped. A light cut taken along a bar between centres indicates any error, which was corrected until the test bar became parallel. The micrometer screw was then advanced to contact its block and the drum set to read zero, then secured with its grub screw and carefully rechecked.

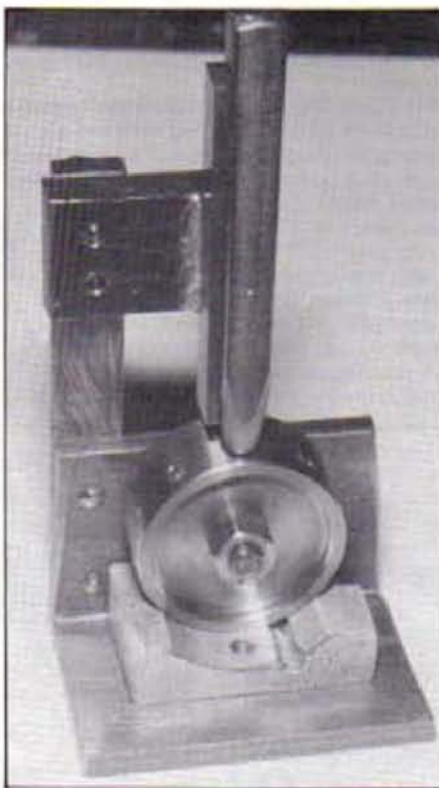
For a simple test I used the device to make a taper pin. This can be seen in **Photo 4**. The standard taper on these is  $\frac{1}{16}$  in. per foot which equals 0.0208 inches per inch so using the formula given previously the micrometer was set at 2.08mm, the tip pressed firmly into contact with the block and the bar clamped. As with all taper turning, the tool must be at centre height. The tool was fed in with the top-slide screw, the autofeed engaged and the pin turned in the usual way. The resulting pin appeared to be a good fit in a hole reamed with a standard pin reamer, which was encouraging so I went on to make an arbor for an old drill chuck I had.

A piece of  $\frac{1}{8}$  in. dia. EN8 free-cutting steel was centred and roughed down in the

larger lathe to the size of the large ends of the tapers which were Jacobs No. 33 and No. 2 Morse. Reference to the invaluable *Model Engineers' Handbook* (Argus Books £6.95 plus 75p p&hp) gives the taper for No. 2 Morse as 0.04995 in. per inch and for Jacobs 33 as 0.76194 in. per foot which equals 0.0635 in. per inch. The micrometer

was set to 4.99mm, the blank mounted between centres and the Morse end turned. The blank was reversed, the micrometer reset to 6.35mm and the other end completed. A guide bar must of course be clamped firmly after each adjustment; the screw is for setting only, not resisting cutting forces.

The resulting arbor was an acceptable fit in both tapers without any further fiddling. As this steel has good machining properties, only a polish with fine carborundum paper was necessary for a good finish. I think this test shows that the device can be an answer to an awkward machining problem.



**Photo 5.** An interesting jig for marking the dial.

### LIST OF SUPPLIERS

Note — The author has no connection with any firm mentioned here.

#### AKRON TOOLS

11, Hawthorn Court, 46 Rickmansworth Road, Pinner Middx. HA5 3UN  
Ground Flat Stock.

#### BOND'S o' Euston Road, Ltd.

Arundel House, Rumbold's Hill, Midhurst, Sussex GU29 9NE.  
Worm Gears.

#### CHRONOS Ltd.

95 Victoria St., St. Albans, Herts.  
Division plates, Free-cutting Silver steel.

#### DAVALL STOCK GEARS Ltd.

Welham Green, Herts AL9 7JB  
Toothed pulleys and belt.

#### G.L.R. DISTRIBUTORS Ltd.

Hartham Lane, Hertford, Herts SG14 1QN.  
Metals, Tufnol, Belting.

#### SHESTO

Unit 2, Sapcote Ind. Estate, 374 High Road, Willesden, London NW10 2DH  
Plastic belting.

#### P.P. THORNTON (SUCCESSORS) Ltd.

The Old Bakehouse, Upper Tysoe, Warwickshire CV35 0TR  
Horological Wheel Cutters.



Dr. R. Cutler designed this small wood-turning lathe for a friend, using the novel idea of treating the motor as a powered headstock. The result is a miniature precision unit ideal for intricate small-scale turning work of particular value in modelmaking. Furthermore, it's straightforward to fabricate from stock materials

*Miniature furniture turning: the matchsticks show the scale...*



# A MINIATURE WOOD TURNING LATHE



*The wood base model with bell chuck in use with Tee rest and tailstock. Box for induction motor incorporates capacitor and switchgear.*

saw is available. The motor feet or plate should be checked on a surface plate to ensure there is no rocking.

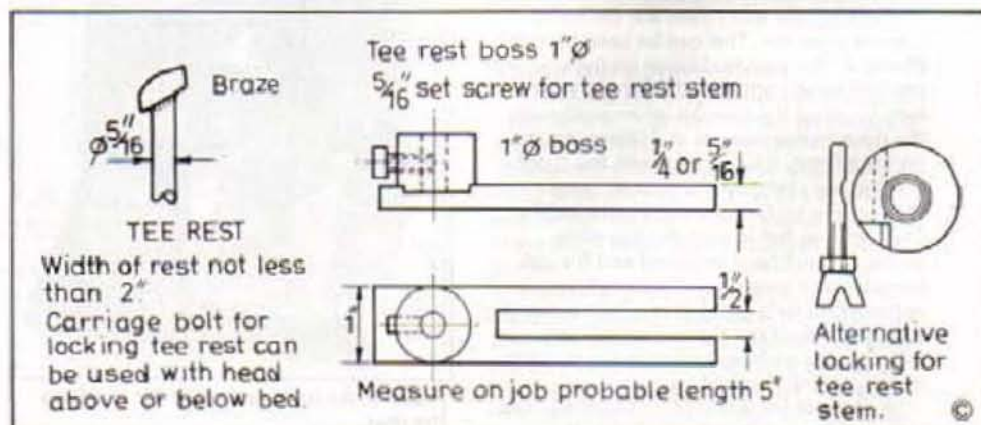
End feet to the lathe bed to allow it to stand between four and five inches above the bench may be found convenient as this

**T**hose woodworkers interested in turning are more fortunate than we metalworkers, as their full or medium size lathes cost a fraction of our own. Miniaturists often working in  $\frac{1}{8}$  scale are, however, less well catered for as, apart from conversions of power drills, the only small lathes available are metal turning types with a built-in precision unnecessary for their work, quite apart from the cross slide hampering free movement of the handheld tools; naturally if metal work is also envisaged, then the considerably greater expense of such types will be justified. A miniaturist friend, working to this scale, producing superb reproductions of antiques, chairs with turned legs little thicker than matchsticks, chests and so on, asked my help in making a suitable lathe. I took this as an opportunity to develop the concept of using a suitable motor as the headstock. "Suitable" in this context calls for a 2750 rpm capacitor start induction motor, horsepower rating between  $\frac{1}{8}$  and  $\frac{1}{4}$ , a shaft not less than  $\frac{1}{8}$  in. dia., either with pedestal feet or a slotted base plate, wired to give anti-clockwise rotation viewed from the shaft end. Such motors can occasionally be found on the surplus market. The only certain source I know is from F. Smith, 26 Victoria Road, Pinxton, Nottingham. Selection and supply from leading makers is easy enough if a hundred or thousand are required, but single orders

do not seem to be encouraged; in any case, a cost of not less than £40 would seem to be usual.

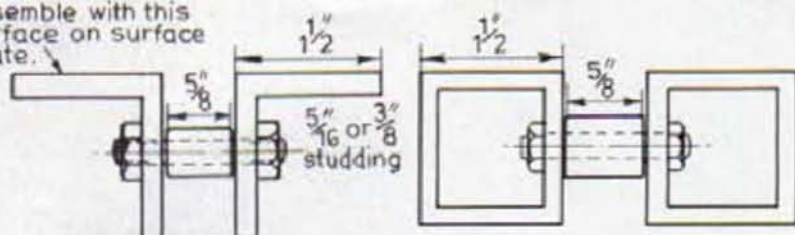
It just so happens that this speed is very suitable for turning anything between a matchstick and a cotton reel or larger, this depending on the horsepower of the motor. Centre height of the shaft should be not less than  $1\frac{1}{2}$  in., an intervening wood base being essential if the bed width does not match the bolting holes of the motor feet or plate. A maximum shaft centre to bed height of slightly more than  $2\frac{1}{2}$  in. is convenient as this allows use of a standard 5 in. dia. circular saw as an accessory, though the height can be less if a 4 in. dia.

allows stowage of the capacitor and switchgear beneath and easy access to the tailstock and tee rest locking nuts. Alternatively, the bed can be left without end feet with locking fixtures actuated from above. The heads of old domestic water taps, particularly if chromium plated, make stylish actuating knobs for these items if the stem is cut off and the hub drilled and threaded. If feet are fitted, the locking hexagon nuts can have arms brazed on with terminal round knobs. Half inch BSW throughbolts and nuts will be used suitably shimmed to allow tightening within an arc convenient to the operator, though spanner operation is an alternative option. Having

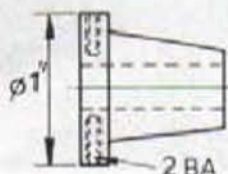




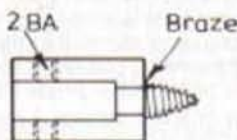
Assemble with this surface on surface plate.



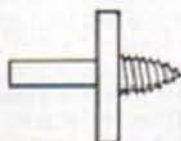
Generous clearance for all holes to avoid distortion on tightening. Assemble on surface plate with Araldite on collar faces. Dural bed member angle or box section spacing collars 1" Ø m.s. centre hole 5/16" or 3/8"



Jacobs chuck adapter 1" Ø m.s., bore to suit motor shaft, cross drill for 2 BA grub screws, taper turn for No2 morse taper.



Screw chuck 1" Ø body drilled for heavy wood screw with head cut off.

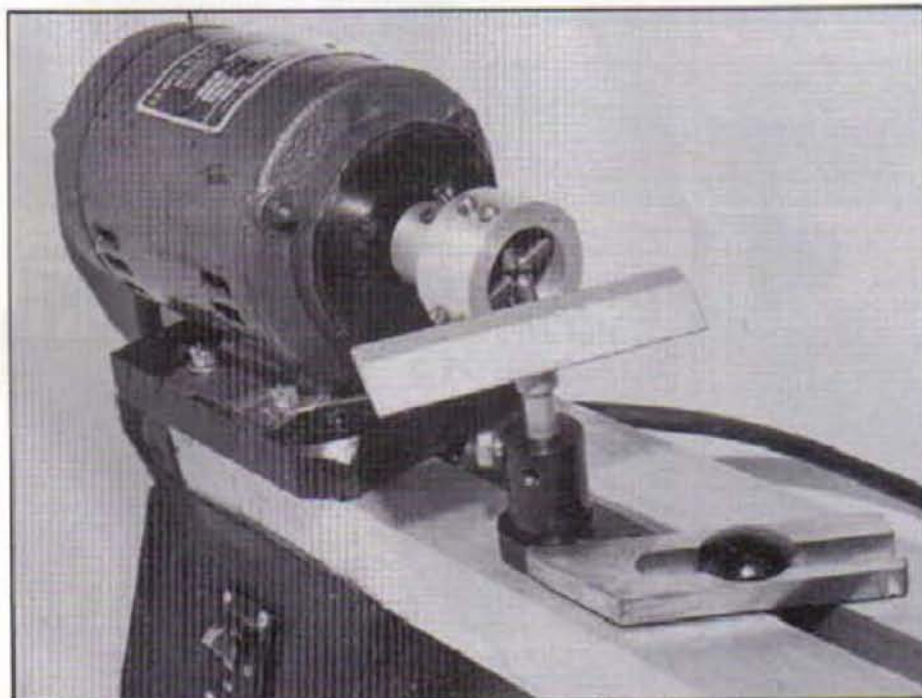


Screw chuck for use in Jacobs chuck heavy wood screw brazed into 1" Ø disc 1/4" thick minimum.

acquired the motor, the overall proportions can be envisaged with a maximum bed length of 24 in. or less, with or without end feet as described above. It is best not to make the lathe too small so there is freedom to work with the tee rest without removing the tailstock. The bed members, if of hardwood, must be not less than 2 in. wide and 1 in. thick. Dural in angle or, better

still, box form is ideal and can often be secured as offcuts from a metal scrap dealer (mine keeps a fine selection!).

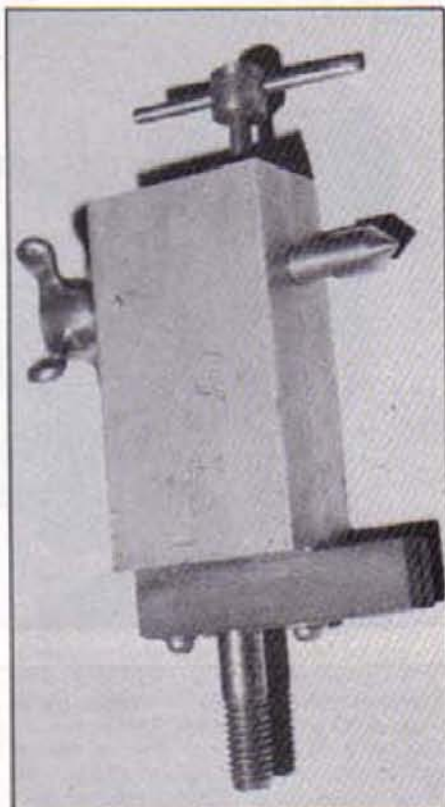
I use my laminate-faced kitchen table as a large surface plate for checking the flatness of the wood members, the opposing faces to be equally flat so that some rubbing down may be required; dural sections in this length rarely need attention



The larger model set up for turning using the bell chuck; bed members are square section dural.

in this respect. The transverse end cross bearers for the wood members specified should be twice each member's width plus 1/2 in., this overall width of 4 1/2 in. should allow room for the motor bolting holes. At this stage two mild steel offcuts of 1/2 in. width are required as temporary spacers for a wood assembly, the bed members being held tightly against them lying flat on the table, the cross members being positioned and glued, using a board and weight on top. When the glue is set, the top of what is to be the working surface should be without warping or distortion, and not subsequently affected by suitable screwing for extra strength.

If dural angle or box sections are used, permanent MS spacers of 1 in. dia. are machined exactly 1/2 in. wide, drilled for easy clearance for 5/8 or 3/4 in. studding, as are the bolting holes in the facing dural sections. The bed members are placed on the table, the collars smeared with Araldite and bolted up. After hardening of the Araldite, the working surface should be dead flat



Tailstock in dural showing tongue extension and tap handle knob.

and the connecting nuts finally nipped up after this has been checked.

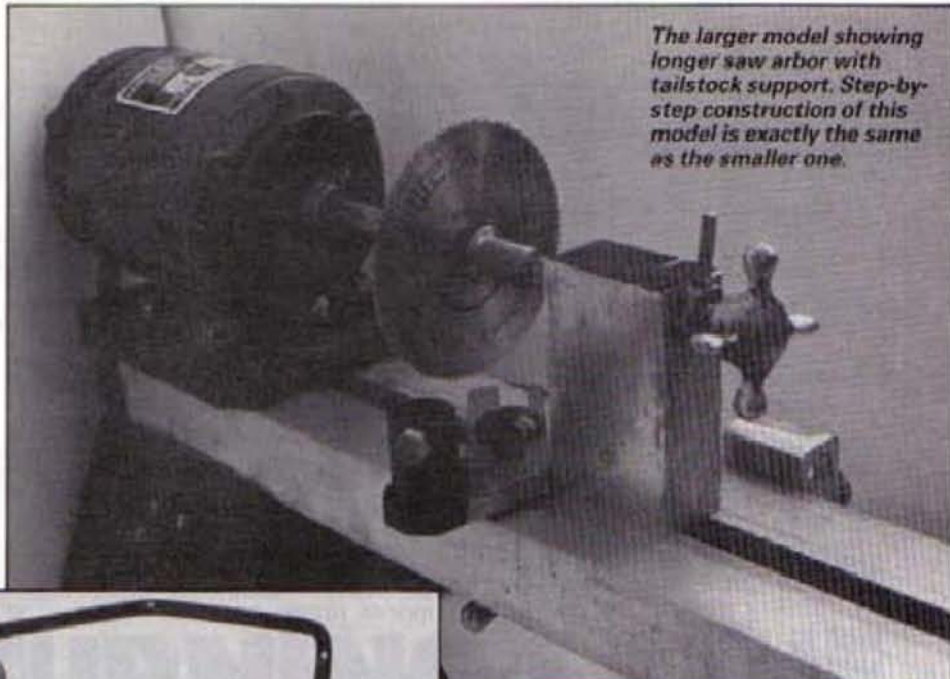
The centre height having now been determined, with the motor bolted directly to the bed members, or with an intervening base, the tailstock should next be made: which should be one inch higher than the desired centre height. It can be of hardwood not less than 1 1/2 in. wide and 3 in. deep, strictly squared up, and with a dead flat base and a centre line scribed all round; alternative patterns are shown, one with a throughbolt allowing the tailstock to be locked either from above or below, the other from below only; the latter allowing more flexibility in the tailstock spindle arrangements. The prepared tongue should then be drilled for the throughbolt and fixing screws with ample clearances.

It can be lightly screwed and checks

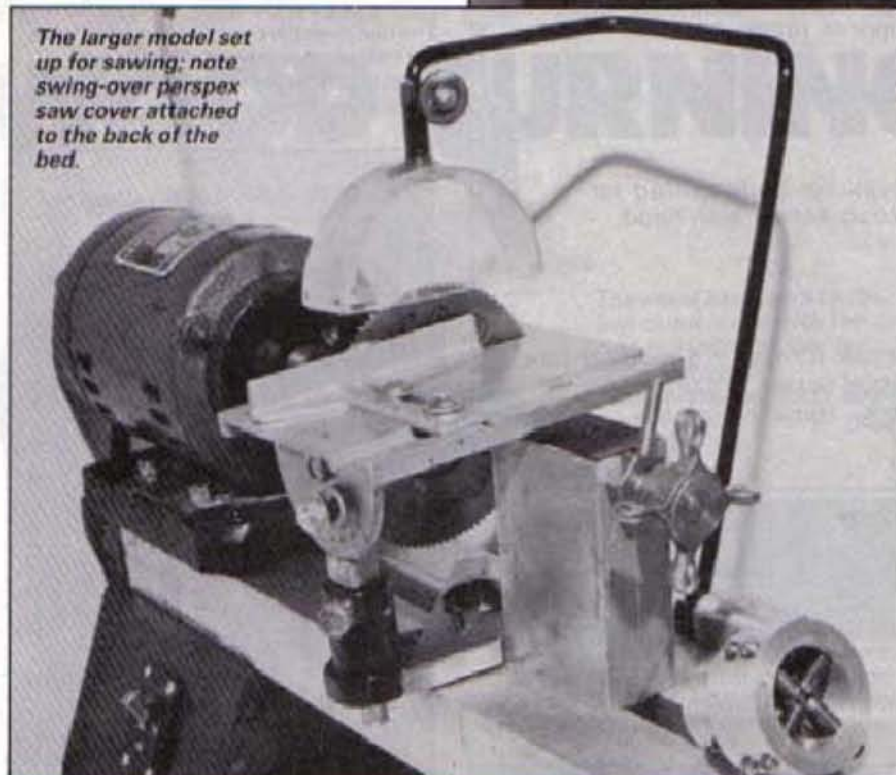


made that the sides of the tailstock are parallel with the outer side of the bed members, after which the screws can be finally nipped up. It should then slide along the bed with a uniform hint of stiffness and without shake. Whilst much work can be done with a screw chuck only (all spindle fittings are made of 1 in. dia. MS or brass stock) a Jacobs 0 -  $\frac{1}{8}$  in. cap. drill chuck with No. 2 Morse taper arbor vastly extends the range and with an extra length drill and test bar will ensure correct lining up.

For this a 1 in. length of 1 in. dia. bar is drilled and reamed to fit the motor shaft and is cross drilled. No. 26 for 2BA grub screws. An offcut of brass is then chucked and reduced to allow a close fit of the prepared section and locked up with the grub screws; it is then taper turned using topside travel only. This should run perfectly truly, and with its own drive screw



*The larger model showing longer saw arbor with tailstock support. Step-by-step construction of this model is exactly the same as the smaller one.*

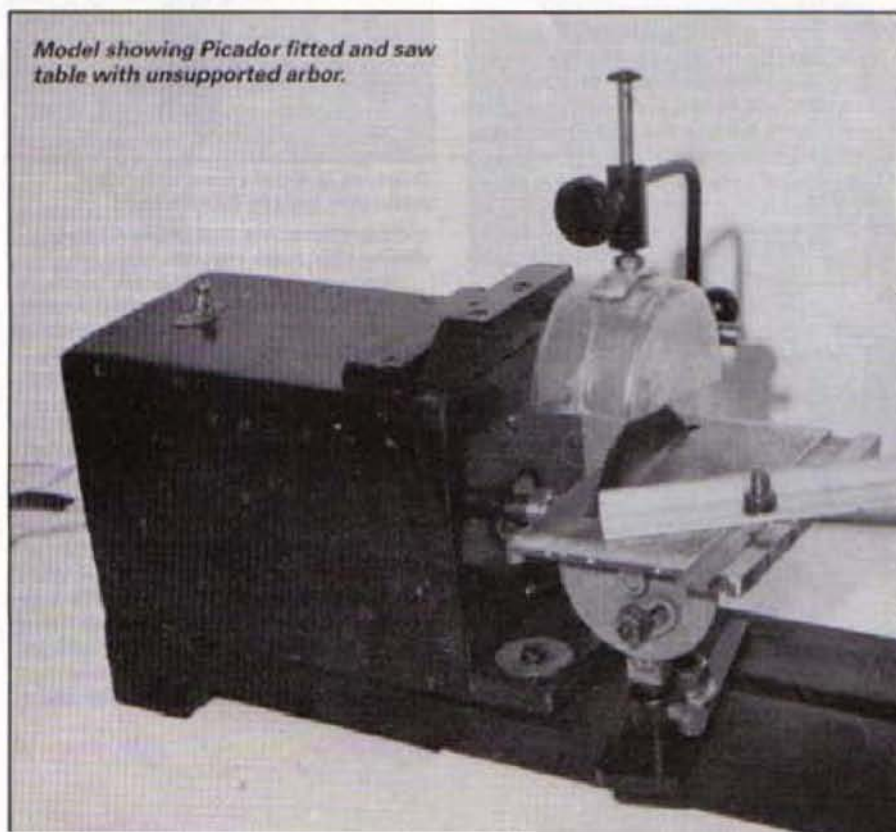


*The larger model set up for sawing: note swing-over perspex saw cover attached to the back of the bed.*

assembly is likely to be in place much of the time the lathe is in use. The test bar will allow lining up of the motor relative to the bed, and the fixing bolt holes spotted and drilled for bolts having ample clearance to allow any final adjustment. A maximum size twist drill is chucked and the tailstock, held firmly down, is advanced when the drill point should be on the centre line; if not, check motor and tailstock alignment and correct suitably. Tighten up the motor bolts, start up the motor and, holding the tailstock firmly, advance manually; with a long drill it should emerge on the back centre line but, if not, regard the drilled hole as a pilot and complete off the job; no through drilling is required for one of the tailstock designs illustrated. The throughbolt for this is a  $\frac{1}{2}$  in. dia., a carriage bolt being used for locking either way.

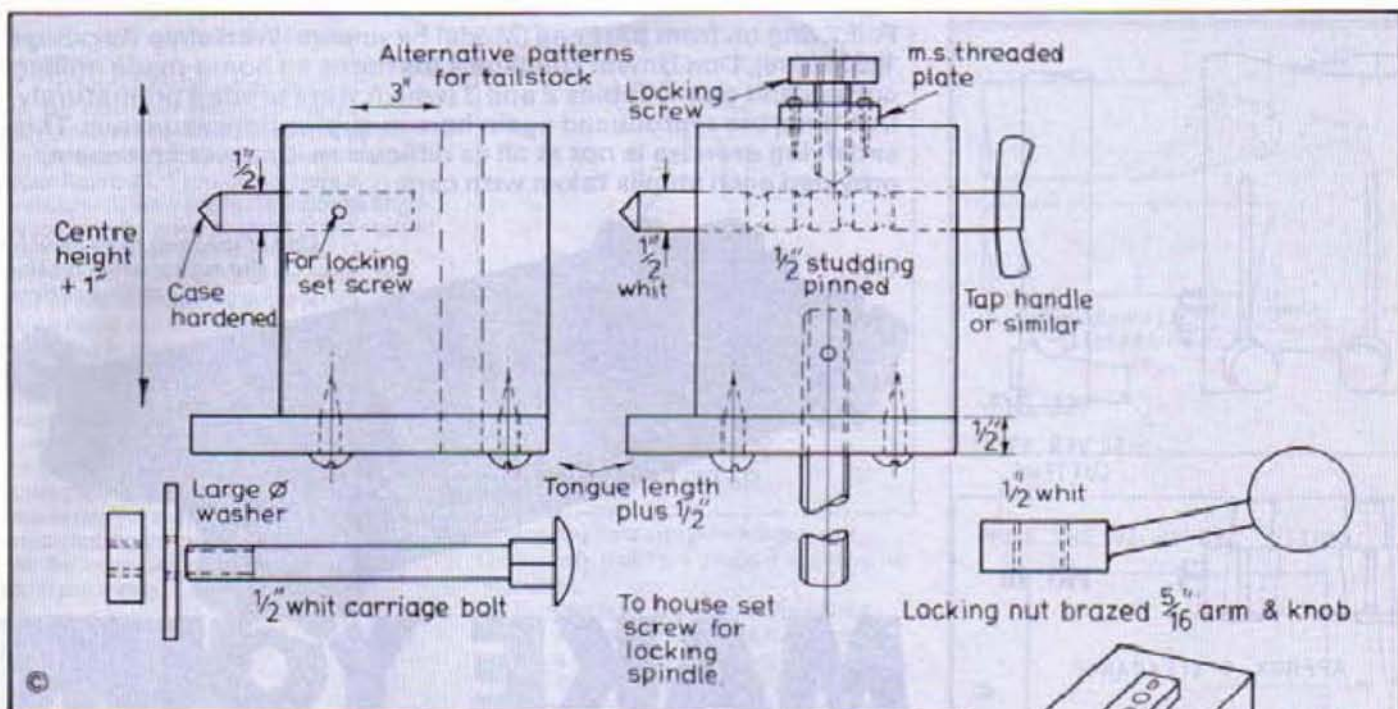
The other pattern is drilled as shown to house a length of  $\frac{1}{2}$  in. BSW studding cemented with Araldite and cross pinned. This type allows a variable length tailstock spindle which also can be made of studding, the tailstock body being suitably threaded. The pointed tip of either type is casehardened.

With my 'Series 2' model having Dural bed members, my friendly scrap dealer provided a length of 2 in. by 3 in. by  $\frac{1}{2}$  in. dural, sufficient for a couple of tailstock bodies, but even for these I used a wooden tongue and the original all-wood construction has worked perfectly well. Dimensions for the tee rest are far best determined by making a mock-up in wood, the only fixed dimension being the  $\frac{1}{2}$  in. slot in the bottom member in which the square



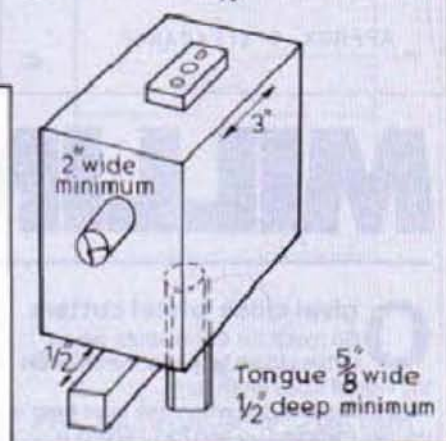
*Model showing Picador fitted and saw table with unsupported arbor.*





beneath the domed head of the carriage bolt will snugly fit; the tee rest body will house the vertical support of a Picador miniature saw table. Both tee rest and any such support being locked by a set screw

or better by a side pin as illustrated. Given a Jacobs chuck fitting, all sorts of accessory can be fitted, as well as drive for the saw table; such as a miniature sanding disc and drill pad whilst a miniature bell chuck of



traditional design can be made as a separate fitting for the motor shaft; the overall design can thus become a true combination machine suitable not only for the craft miniaturist, but for aeromodeling and allied hobbies.

It is true that for the dedicated miniature woodworker any old motor screwed to a baseboard with a block of wood for the toolrest will allow a surprising amount of work to be done, such is his mastery of his handheld tools. However, if in such a project our mechanical disciplines can also be faithfully followed, both maker and user can find themselves content.



*The locking method used by the author for the Tee rest boss on his miniature lathe.*

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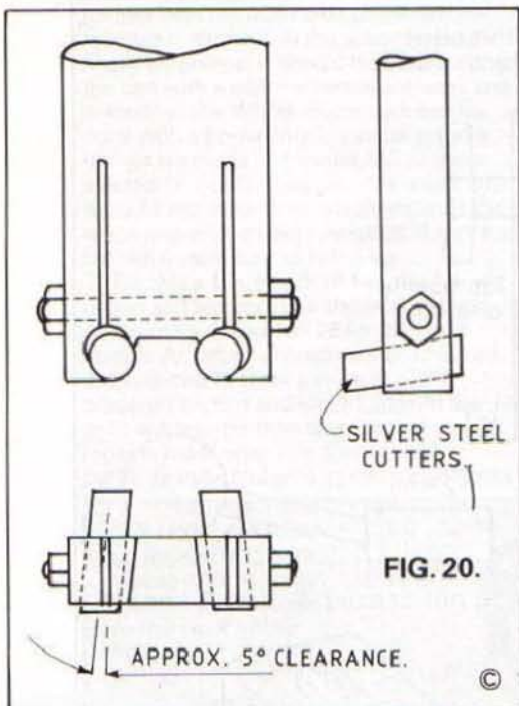
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Following on from part one (Model Engineers' Workshop Aug/Sept 1991 issue), Don Unwin concludes his notes on home-made milling cutters and gears. Tables 2 and 3 (which were printed prematurely last time) are reproduced again here in appropriate sequence. This satisfying exercise is not at all as difficult as it may at first seem, provided each step is taken with care



One of the form tools used by the author when making milling cutters.

# MAKE YOUR OWN MILLING CUTTERS &

## Ogival clock wheel cutters

So much for the involute wheel cutters; now let us concentrate on the Ogival clock tooth form.

For clockmaking where the gear train is usually stepping up and low friction is more important than a constant velocity ratio, the Ogival approximation to the epicycloidal tooth is frequently used. There are a number of variants but the one I have used successfully is the one-third Ogive in which the tooth form is not dependent on the gear to pinion ratio. If any reader should prefer to use any other form, the same method of making form tools to construct the cutters can be applied. Unlike involute gear cutters, I use single point flycutters for gears which are almost invariably of brass, but use multi-toothed cutters for pinions which are made of steel.

## Proportions

Table two gives the proportions of shape for 1 D.P. or module-one pinion. As in the case of involutes, to get the values required:

Divide by the D.P., dimensions in Imperial. Multiply by the module, dimensions in metric if a metric module.

Note that in this case the flank angle  $\theta$  should be chosen to suit the number of teeth the cutter is going to be used to cut. Table three gives the same values for gear wheels.

In addition to the basic proportions, I have also given values for a few common D.P.s used in clock work. It will be seen that even in the case of the larger teeth sizes such as 34 D.P., typical of the size used on a clock great wheel, the radii  $R$  and  $r$  are quite small. This together with the need for radial flanks, demands a different approach from that used to make involute shapes.

Taking the coarser pitches of gears, say

from 40 D.P., I made pin form tools similar to those described for involutes. The main difference was that the pins consisted of short pieces of hardened silver steel of the required diameter ( $2R$  or  $2r$ ), and no attempt was made to achieve the correct centre distance. The holes to receive the pins were drilled about half an inch apart at an angle of about five degrees from the vertical, in such a manner that both side and front clearance are given to the cutting edge **figures 19-20**.

The blank can be either a piece of square cast steel for a flycutter when making wheels from brass or light alloy, or a prepared disc for a multi-tooth cutter to

machine harder materials such as steel. This is mounted in the lathe and the pin form tool is mounted in the toolholder with the two cutting edges parallel to the lathe axis. Using the appropriate cutting pin, one side is carefully machined to the correct depth ( $r + b$ ). The amount to be machined from the side of the blank is given by:-  
Blank thickness  
 $S-2$

After completing the first side, machine the other side using the opposite cutting point. By careful measurement of the blank, and use of the top slide indices, the correct thickness 'S' can be achieved. It can be checked by direct measurement with a

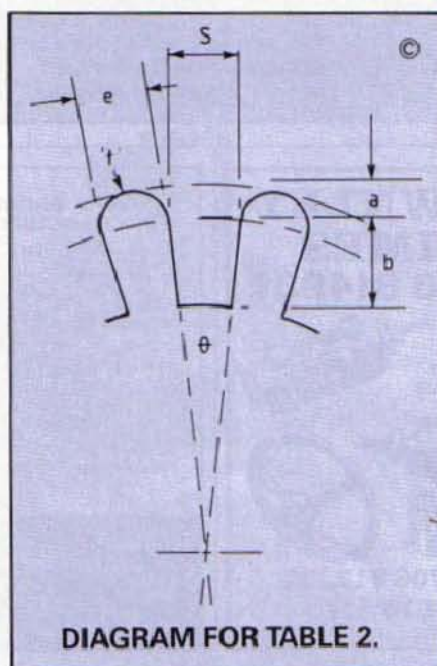


DIAGRAM FOR TABLE 2.

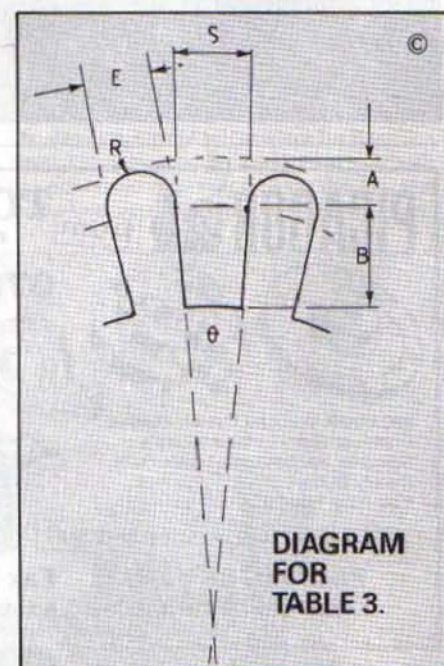
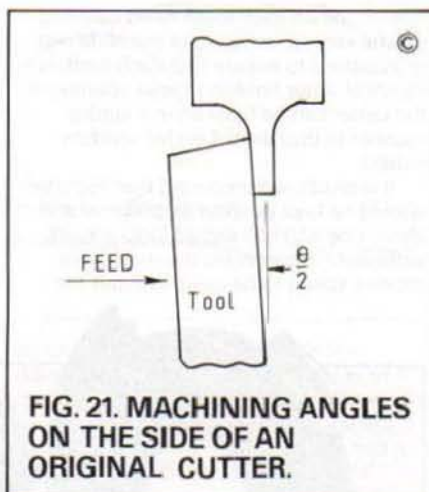


DIAGRAM FOR TABLE 3.



micrometer; if anything it should be under, not oversize.

The form tool can be removed and a parting tool or something similar suitable for cutting on the side is set at the correct flank angle ( $\theta/2$ ) and used to machine the taper **figure 21**. If you do not have a protractor to set it up, make a simple angle gauge out of a piece of sheet metal marked out with a plastic protractor, or to dimensions from a table of tangents. Take care in this operation to avoid removing too much metal and so producing a step where the radius is tangential to the flank. To ensure the best possible finish and therefore obtain minimum friction of the gears, carefully oilstone all tools to a keen smooth edge by rubbing the oilstone along the cutting edge, not across it. Use a slow cutting speed and plenty of oil, take great care to get the shape symmetrical and, when making the multi-tooth cutters, to use the index dial in order to repeat each tooth accurately.

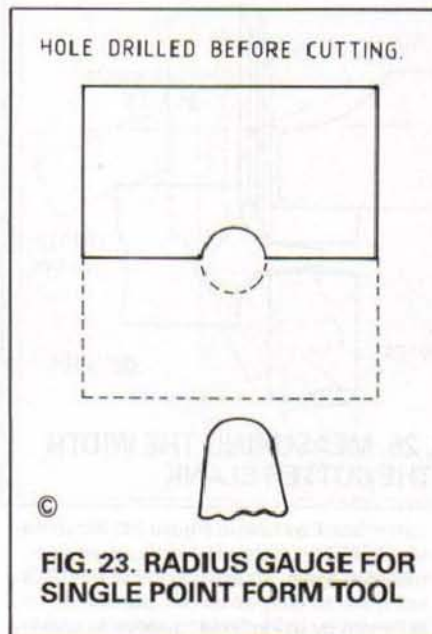
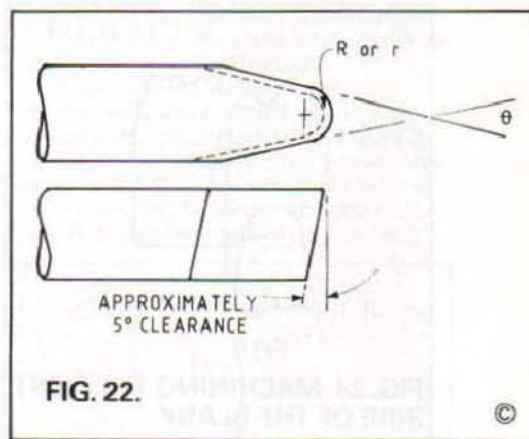


or filing the flats and then hardening it. Once again, making a gauge if you have no protractor.

To make such a gauge, simply drill a hole in a piece of thin metal sheet, taking care that it is round and is not oversize. Remember the hole must be  $2r$ . Cut across the metal so that just a fraction under half the hole is left and remove all burrs. We now have a radius gauge which is worth keeping for future use if it is marked with the radius. **Figure 23** shows the method of making the gauge.

Having checked the tool radius with the gauge, the tool can be filed or oilstoned to the correct shape, using an eyeglass to make sure it is correct. A tip here is to use a slide projector as a shadowgraph, projecting the image on a white background. If any light shows through, then surgery is needed to the tool to get it right.

Set the completed tool in the lathe toolpost with the angle symmetrical with the lathe axis. Machine one side of the



# DOWN GEARS

## Small radius cutters

The radius 'r' is too small to use this method when making the finer pitches. In this case I use a single tool only, **figure 22**. Grind the side faces to the correct flank angle  $\theta$ , ensuring the faces are straight and have about five degree clearance. If you prefer, you can make it of cast steel, milling

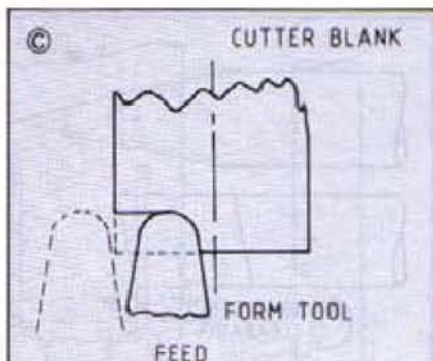
**TABLE 2**  
**OGIVAL CLOCK TOOTH PROPORTIONS**  
For 1 DP or 1 Module  
PINION 1/3 OGIVE

| DP     | 1                                  | 34    | 40    | 42                                 | 44    | 48     | 52    |      |
|--------|------------------------------------|-------|-------|------------------------------------|-------|--------|-------|------|
| a      | 0.74                               | 0.022 | 0.019 | 0.018                              | 0.017 | 0.016  | 0.014 |      |
| b      | 1.75                               | 0.052 | 0.044 | 0.042                              | 0.040 | 0.037  | 0.034 |      |
| s      | 1.99                               | 0.059 | 0.050 | 0.048                              | 0.045 | 0.042  | 0.038 |      |
| r      | 0.77                               | 0.023 | 0.019 | 0.018                              | 0.017 | 0.016  | 0.015 |      |
| a+b    | 2.49                               | 0.074 | 0.063 | 0.060                              | 0.057 | 0.033  | 0.048 |      |
| e      | 1.15                               | 0.034 | 0.028 | 0.027                              | 0.026 | 0.0239 | 0.022 |      |
| N      | 6                                  | 7     | 8     | 9                                  | 10    | 11     | 12    | 13   |
| 0 deg. | 30                                 | 25.5  | 22    | 20                                 | 18    | 16     | 15    | 13.8 |
| a,A    | Addendum = 0.74<br>dp              |       |       | b,B Dedendum = 1.75<br>dp          |       |        |       |      |
| e,E    | Tooth width = 1.15<br>dp           |       |       | r,R Radius = 0.77<br>dp            |       |        |       |      |
| s,S    | Space width = 1.99<br>dp           |       |       | d dia. of blank = $N + 1.48$<br>dp |       |        |       |      |
| θ      | Angle of radial sides = $180$<br>N |       |       | N Number of teeth                  |       |        |       |      |

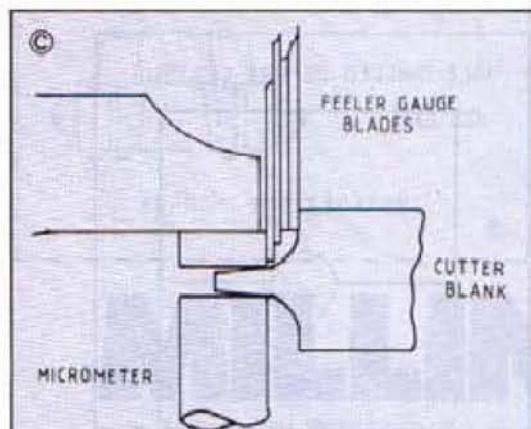
**TABLE 3**  
**OGIVAL CLOCK TOOTH PROPORTIONS**  
For 1 DP or 1 Module  
GEAR

| DP         | 1    | 34    | 40    | 42    | 44     | 48           | 52    |                                       |
|------------|------|-------|-------|-------|--------|--------------|-------|---------------------------------------|
| A          | 1.35 | 0.040 | 0.034 | 0.032 | 0.031  | 0.028        | 0.026 |                                       |
| B          | 1.55 | 0.045 | 0.039 | 0.037 | 0.035  | 0.032        | 0.030 |                                       |
| S          | 1.57 | 0.046 | 0.039 | 0.038 | 0.036  | 0.033        | 0.030 |                                       |
| R          | 1.57 | 0.046 | 0.039 | 0.038 | 0.036  | 0.033        | 0.030 |                                       |
| A+B        | 2.90 | 0.085 | 0.073 | 0.069 | 0.066  | 0.060        | 0.056 |                                       |
| E          | 1.57 | 0.046 | 0.039 | 0.037 | 0.0356 | 0.0326       | 0.030 |                                       |
| Cutter No. |      | 5     | 4     | 3     | 2      | 1            |       |                                       |
| N          |      | 21/25 | 26/34 | 35/54 | 55/134 | 135/<br>Rack |       |                                       |
| θ deg.     |      | 9     | 6.9   | 5.1   | 3.3    | 1.3          |       | Parallel for<br>Practical<br>Purposes |





**FIG. 24. MACHINING THE FIRST SIDE OF THE BLANK**



**FIG. 25. MEASURING THE WIDTH OF THE CUTTER BLANK**

cutter blank as before **figure 24**. Move the tool to the opposite side and proceed to machine again. Measuring the width 'S' is not quite so easy as before, but can be achieved by using feeler gauges as shown in **figure 25**. First select a stack of feelers equal to 'r' and hold these on the shoulder of the tooth, resting the micrometer anvil on them whilst taking the micrometer reading. Once the initial measurement has been made, the index collar figures can be noted and used to get the correct size.

When making multi-tooth cutters, the

operations on each tooth need care and careful setting or noting of the slide rest graduations to ensure that each tooth is identical. After finishing these operations, the cutter can be finished in a similar manner to that described for involute cutters.

It is worth remembering that flycutters should be kept as short as practical and about one and half inches long is quite sufficient. This enables the maximum rotative speed to be used, without the

small mark on the circumference of the blank. With the machine stopped, the cutter can be lined up with surprising accuracy. See **figure 28**.

Care must be taken during cutting not to force the cutter into the work, as there is a danger that the teeth already cut may be bent over. This is particularly important when fly cutting. Also important is the need to ensure that the axis of the blank is parallel to the machine traverse in all planes. Ensure the backlash in the driving mechanism is always taken up in the same

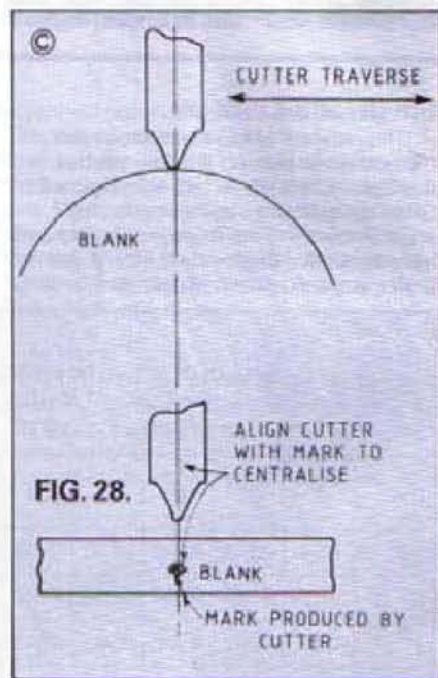


**Fig. 26. Involute and ogival multi-tooth cutters and a single point gear cutter; note that each is marked for its particular purpose.**

cutting speed becoming too high and causing permanent failure of the edge. **Figure 26** shows involute and Ogival multi-tooth cutters and a flycutter.

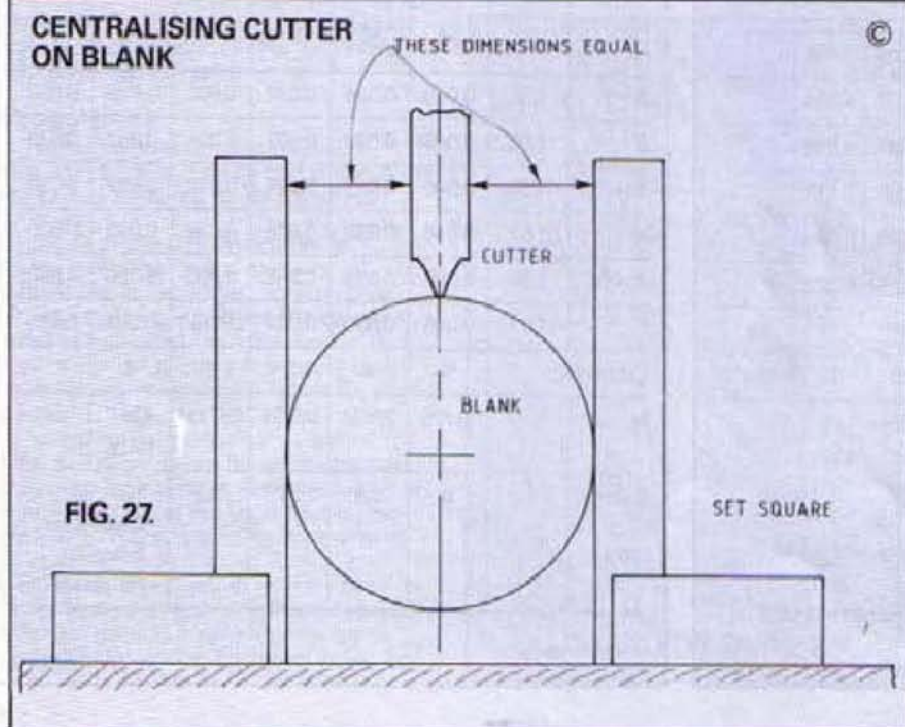
### Cutting gears

One or two tips about the actual gearcutting operations may be of interest. It is very important to get the cutter exactly over the centre of the gear blank, otherwise the teeth will be lopsided. One method is to put a square against each side of the gear blank and measure the distance from each side of the cutter, **Figure 27**. Another trick is to run the machine and advance the blank until it just touches the cutter, using a piece of cigarette paper stuck on with oil as a witness. Move the blank laterally under the still-rotating cutter so producing a very



**FIG. 28.**

ALIGN CUTTER WITH MARK TO CENTRALISE  
BLANK  
MARK PRODUCED BY CUTTER



**FIG. 27.**

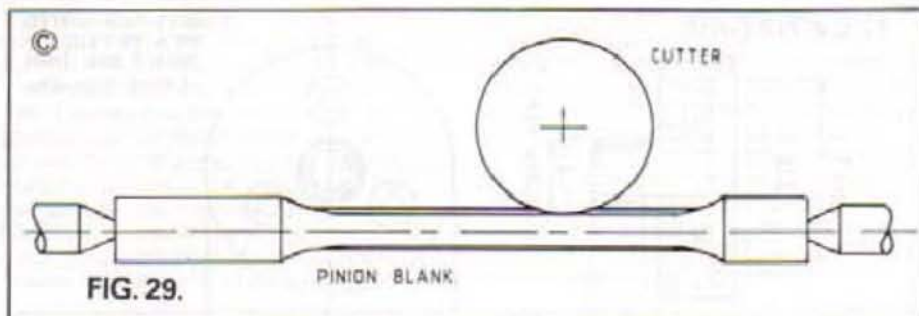
direction.

When cutting larger teeth, locking the mandrel supporting the blank at each cut is a useful precaution. Sometimes one side of the cutter may become slightly dull and push the blank round whilst cutting and so producing an inaccurate gear. As always, check through the first tooth again to ensure that there has been no shift. Also count the number of teeth; I had a case when the blank slipped and gave me three extra teeth but still went through the first tooth exactly.

### Small pinions

When producing small pinions, I find the best method is to cut a short length of material and mount it between centres, or in a collet and centre. To make it as stiff as





possible, larger material than necessary is used, turning down to size only the part to be cut with teeth. A head must often be left on each end to support the centres, as in figure 29.

### Bevel wheels

Bevel wheels cannot be cut correctly unless they are generated on specifically designed machines; however, acceptable gears, certainly adequate for say a traction engine differential, can be made by the amateur using cutters of the type already described.

It is necessary to make two cuts through each tooth, so that each flank of the tooth is on a radial line to the centre of the cone of the bevel wheel.

### Repairing gears

When undertaking gear repairs, some interesting detective work is sometimes necessary to discover what the damaged

wheel originally consisted of. If the diameter can be measured, there is no problem as the D.P., etc. etc., can be worked out from this. However, if it is completely stripped, it is worth remembering that just as the outside diameter of a blank is  $\frac{n+2}{D.P.}$  so the diameter at the bottom of the teeth (ignoring root clearance if the wheel is stripped will still be present) is  $\frac{n-2}{D.P.}$ .

We can therefore establish the D.P. and O.P. from D.P. =  $\frac{n-2}{\text{Stripped Diameter}}$ . The number of

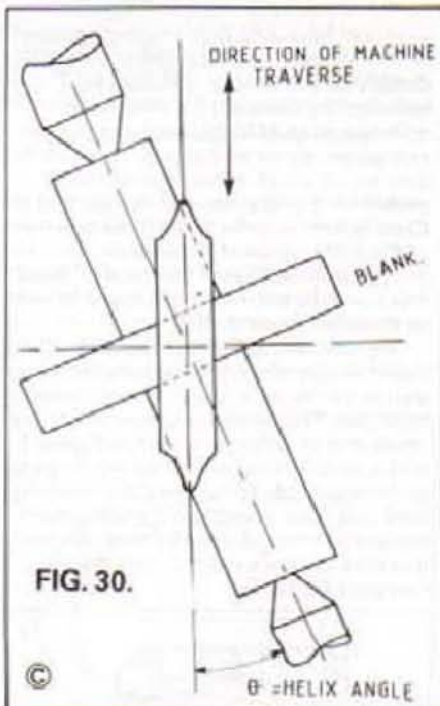
teeth can usually be seen on the stripped blank, or determined from the associated train of wheels.

### Spiral gears

Whilst cutting spiral gears requires a universal milling machine, provided the width of the wheel is not too great and the angle not too excessive, workable gears can be cut by setting the axis of the gear blank at the required angle to the cutter

and the feed. In this case the cutter must be set central on the blank, when it is in the middle of the width. **Figure 30**

Finally, I have included some photographs which should help to make things a little clearer to readers. **Figure 31** shows a group of gears which I have made at various times. One item of interest may be the sprocket for a cine-projector on the left. Although not a gearwheel, the teeth

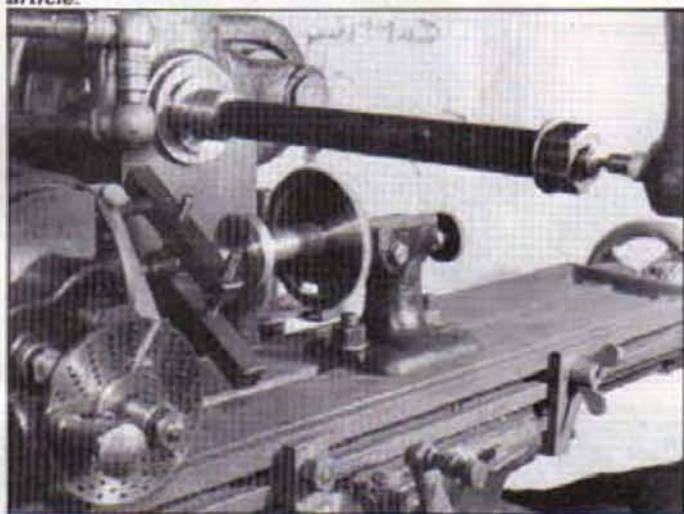


were cut to involute form, with a circular pitch equal to that of the film perforations. **Figure 32** shows the teeth of a clock great wheel being cut with a fly-cutter on the milling machine. **Figure 33** shows a length of steel pinion being cut using a multi-tooth cutter.

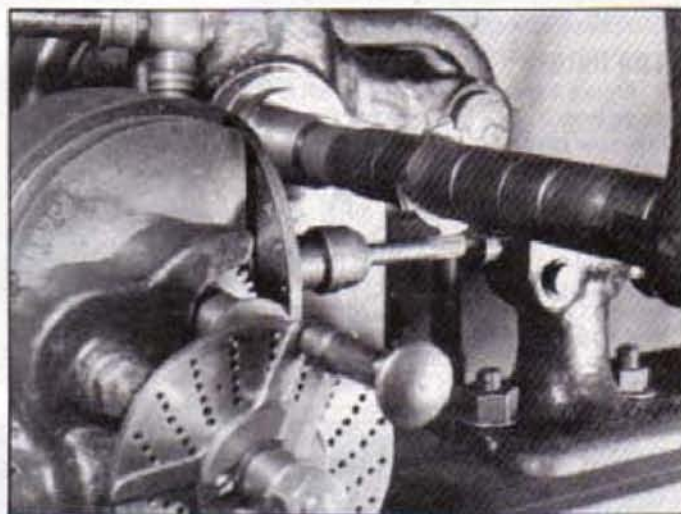
Hopefully, my article will have encouraged readers, stumped by the mysteries of making milling cutters and cutting gear wheels, to have a go for themselves. As long as each step is carefully taken, it is not as difficult as it would seem at first glance, and it is probably one of the most satisfying of operations that can be carried out in the model engineer's workshop.



**Fig. 31.** A group of gears made by the author by the methods discussed in this article.



**Fig. 32.** Cutting a clock wheel by use of a fly-cutter on the horizontal milling machine.



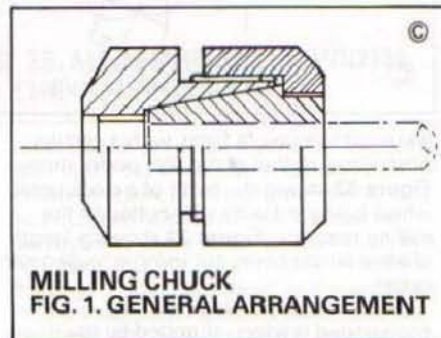
**Fig. 33.** A pinion length being cut by the use of a multi-tooth cutter.



**W**hen I had to mill a large rebate along the length of a rectangular bar, I considered that the drill chuck on my Compact 5 was not really man enough for the job. I looked at the cost of a commercial chuck and came to the conclusion that it was out of proportion to the amount of use that I would get from the tool, so I decided to have a go at making my own.

Fortunately, I had kept an article written by the late Arnold Throp in the *Model Engineer* for 5 July 1985 which gave details of four types of milling chuck to screw directly on the nose of a Myford ML7 spindle. The Compact 5 milling head spindle has an M14x1 thread and a comparatively small diameter shoulder for a screw-on chuck to butt against, so I picked Mr Throp's shortest design, that for Clare collets, in order to keep the overhang of the cutter as short as possible. An incidental advantage of this type of chuck is that it will happily hold plain shank as well as threaded shank cutters.

My machine is a metric one and therefore any tooling that I make for it is also to metric dimensions; it seems logical to do this. The general arrangement of the chuck and its collets is shown in **Figure 1** and is quite normal except for the threads. According to Mr Throp, the Clare company itself used non-standard Whitworth-form threads so mine, although metric, are not that odd. They are easily cut on the Compact 5 anyway.

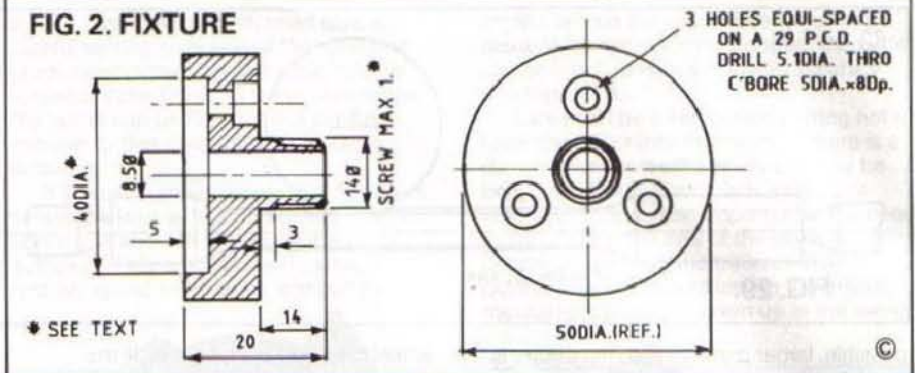


Since the chuck was to be mounted on the M14x1 thread of the milling spindle, it was first necessary to duplicate this thread on the nose of the lathe spindle. I have a No. 1 Morse Taper arbor with a suitable thread which could have been used in the spindle nose with a No. 1-2 Morse Taper sleeve but I was not happy about the drive being slip-free. I therefore made up a fixture to mount on the spindle nose.

### The fixture

**Figure 2** shows the fixture, which is made from a piece of 50mm bar. Grip it in a three-jaw chuck, face the end and then turn a spigot about 15mm diameter to a length of 14mm. Reverse the piece in the chuck, face it to length and machine the recess to take the lathe spindle nose. The fixture should fit the nose as closely as possible, so only the nominal diameter of the recess is given on the drawing. Mine came out spot on 40mm, which gave a clearance of 0.02mm on diameter. Once the recess is to size, the three holes for the set screws can

**FIG. 2. FIXTURE**



be drilled and counterbored and the fixture mounted directly to the lathe spindle for finishing to ensure concentricity. The spigot can now be turned to 14mm diameter for the thread and the faces and outside diameter skimmed so that everything runs concentrically.

The thread is, of course, screwcut and must duplicate the one on the milling spindle as closely as possible. I do not have a thread mike and checked mine by the old 'three-wire' system. I did not bother to look up tables for the proper size of wires to use but merely used three small lengths of silver steel of a diameter which would contact only the flanks of the thread of the spindle and measured over these. It sounds a bit haphazard but since only a comparative reading was required, the

arrangement worked. I don't even know what diameter wires I used! Incidentally, since the lowest speed of the Compact 5 is 200rpm, I do all my screwcutting by hand with a mandrel handle fitted.

The drawing of the fixture shows a hole drilled through it. This is not strictly necessary but can be a help in clearing away any build-up of swarf when the fixture is used.

### The body

Once the fixture is completed, it can be removed and work started on the body and nut, **Figures 3 and 4**. Refit the three-jaw and chuck a piece of 40mm bar. Face and chamfer the end, then drill and bore 13.10mm through. After counterboring and

**Different machines have different fittings in which to secure collets. Gordon Lewis tells us how he made a collet chuck for the Emco Compact Five Milling Machine and also describes the making of the collets. His methods would be equally applicable to other machines in the Emco range**

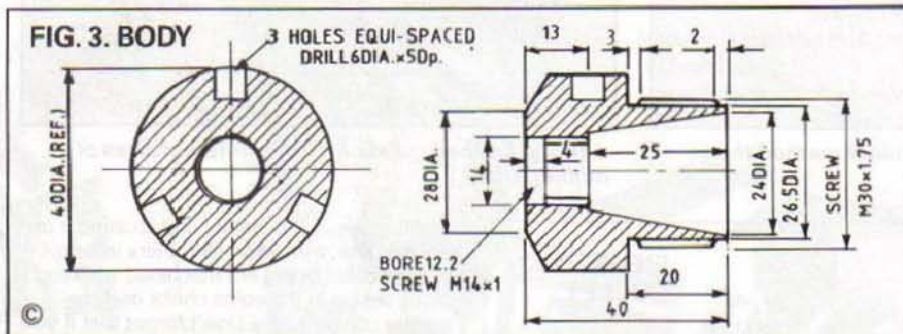


# A COLLET CHUCK FOR



forming the internal recess, screwcut the 14x1mm thread. This must be a good fit on the fixture (and, of course, the milling spindle) to assist in its location. All the remaining machining of the body is done with it screwed on the fixture to ensure concentricity but before screwing the body on, drill the three pin-spanner holes and make at least one of the spanners so that you can unscrew the body after finishing. I hadn't considered this and had to resort to a pair of pipe grips, which didn't do the outside diameter a lot of good. My chuck

them as required. The taper on each must be machined at the same topslide setting as we used to bore the body of the chuck so as to ensure a good fit. You will probably have broken down the original setting to do the screwcutting on the body and nut, so it means that the topslide must be reset to the 10 deg. angle with the aid of a dial test indicator, reading from the internal taper of the chuck body. A test piece should be made and checked with marking blue against the internal taper of the body to ensure that everything is correct.



had to be cleaned up and is a bit undersize, so be warned! The dimensions of a suitable spanner are shown in **Figure 6** and you will need two of them.

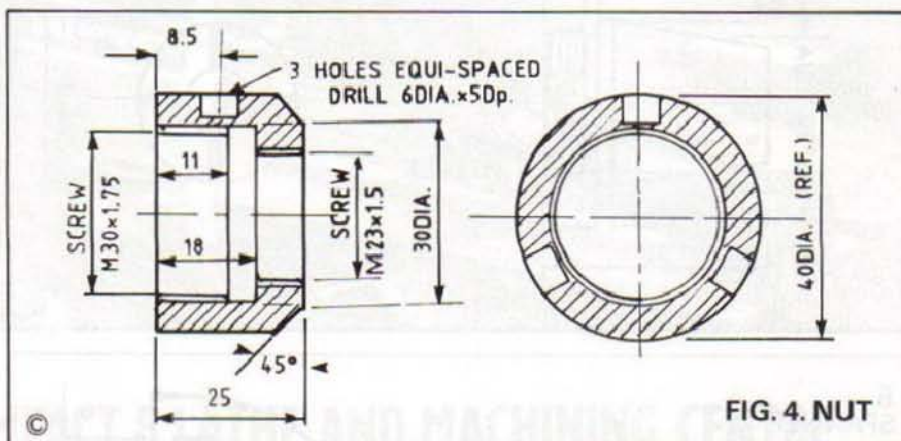
In his article, Mr Throp shows spanner flats on both the body and nut. They mean less work as you don't have to make special spanners but, since my chuck is not hardened as is a commercial one, I felt that it would stand up to the use of pin-spanners better than open-ended ones. If the holes become too battered in use, they can always be opened out or alternative ones drilled. Machining the rest of the body, including the tapered bore, is quite straightforward.

### The nut

**Figure 4** shows the nut, which is also made from a piece of 40mm bar. Set it up in the three-jaw, face one end and bore through 19.80mm. Counterbore and internally recess, then screwcut 30x1.75mm for a nice easy fit on the body. To ensure concentricity of the two internal threads, the 23x1.5mm thread can be cut with the nut screwed on the body, as can the rest of the machining. Again, make sure that you have drilled the pin-spanner holes in the nut so that you can be certain of getting it off without damage. My pin-spanner holes broke through into the thread due to my butchery but this had not caused any problems in use. Indeed, if you wish, you can take the three holes right through. Also, there is no real need to use a flat-bottomed drill. The last thing to do to is to take a skimming cut over both the nut and body to clean them up.

### The collets

The collets are shown in **Figure 5** and the number that you need depends upon how many different sizes of cutter shanks you have, also whether or not they are threaded. It is best to make a number of blanks at the same time and then finish



Once the topslide has been reset, it must be left at that position until all taper turning on the collets has been completed. There are probably several ways of making the collets but the following is the one that I used. It is a bit tricky but saves a lot of resetting.

Take a length of 25mm bar, long enough to make all the collets you require plus a little over as a chucking piece, set it up in

*The fixture; note the spanner hole.*



*A study of the completed assembly.*

the three-jaw and centre drill the other end using a fixed steady on the overhanging end. Remove the steady and support the end with the tailstock centre. The tapered part and the outside diameter of the thread of each collet can now be turned and you can be sure that each one is the same. I found it easiest to work from right to left,

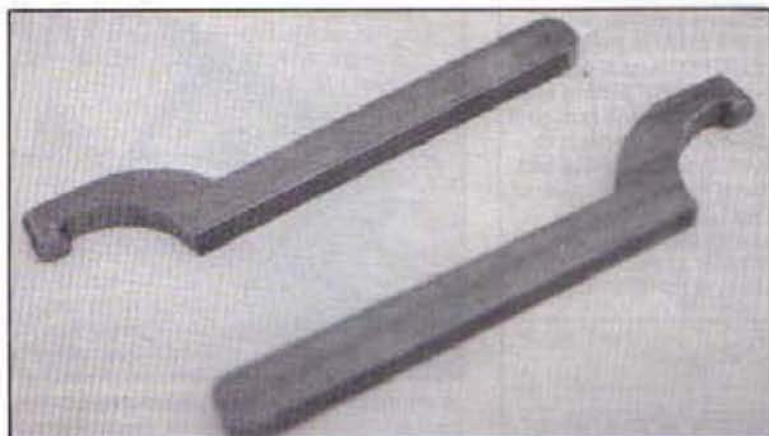


*Above, an internal view of the closing cap.*

completing each before moving to the next one. Taper feed is put on with the topslide and longitudinal feed by the leadscrew handwheel. The sketch in **Figure 7** shows the arrangement. Each of the blanks can now be screwcut to fit the nut. Provided that you note the various dial readings when you have got the first thread correct, you can make all the others the same. When all the blanks have been screwcut, they can be parted off from the bar, again

# OR THE COMPACT 5

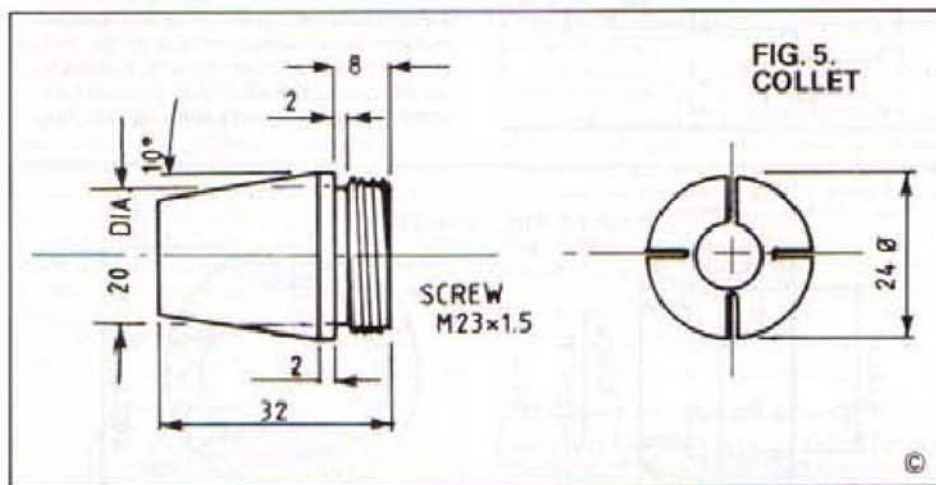




The tightening spanners; this is a more convenient method than using ordinary spanners.



A trio of finished collets for three different sizes of milling cutter.



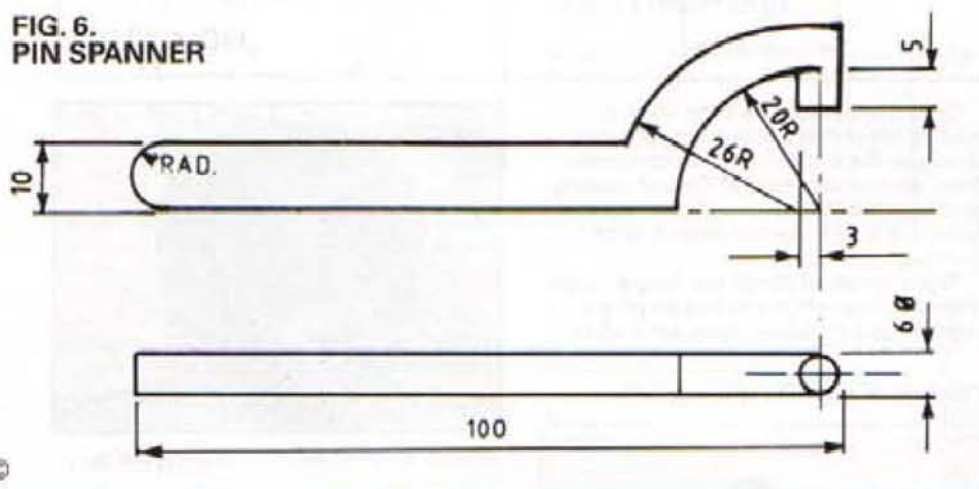
making use of the steady and locating it on each of the 2mm wide diameters in turn.

The collet bores are machined with each blank set up in the collet chuck itself to ensure concentricity. Don't forget that if you have screwed shank cutters, the blanks must first be drilled tapping size and then counterbored and reamed to the cutter shank size. The thread can then be screw-cut or tapped. I don't know if there should be a fine or coarse fit of the cutter thread but I made mine quite sloppy. I reasoned that, since the collet is to be split and compressed on to the cutter shank, it did not really matter how good (or bad) the fit of the thread originally was. This may worry the pundits but all I can say is that it works.

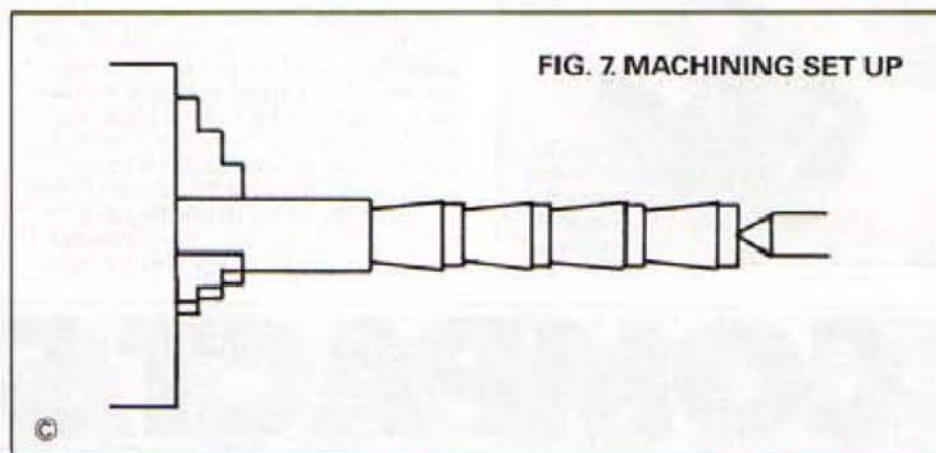
### Slotting the collets

The last thing to do on the collets is to cut four slots at 90 degrees. I used a 1.5mm thick slitting saw, taking one slot through to the bore and the other three to within about 1.0mm. If you have the Emco dividing head, this is a simple job. The 3-jaw chuck can be fitted to the head and each collet in turn mounted on a suitable mandrel. If no dividing head is available, use the jaws of the four-jaw chuck to mark the slot positions. In use, the chuck holds the cutters truly and has done all that I had hoped. I have a 1/2 in. slot drill (yes, I know it's not metric) which I have used to churn off mild steel as fast as the machine would take it on a cut 8mm wide and 4mm deep with a perfectly good finish.

**FIG. 6. PIN SPANNER**



**FIG. 7. MACHINING SET UP**



It is interesting to compare this chuck with that published in the June/July issue; as this chuck uses a slow taper it can easily function with milling cutters without threaded shanks which the earlier design could not, other than for the very small sizes. The earlier design would work quite adequately with the assembly only finger tight, both to close the collet and subsequently to open it.

In this excellent article by Mr Lewis he makes no mention of the essential nature of the comparative thread pitches. I can anticipate some reader making these collets and trying to economize on effort by making the two thread pitches identical, so as to avoid setting up the change wheels twice. Be warned, the difference in pitch is an essential feature to ensure the collet is jacked out of its taper housing when opening for withdrawal of the cutter.

It's an intriguing thought also that, if the drawings were misread and the collet thread made the coarser of the two, I feel it would be possible to assemble and tighten the chuck but would then become impossible to undo. Anyone willing to give it a try? A candidate for a non-reusable executive toy maybe! Ed.





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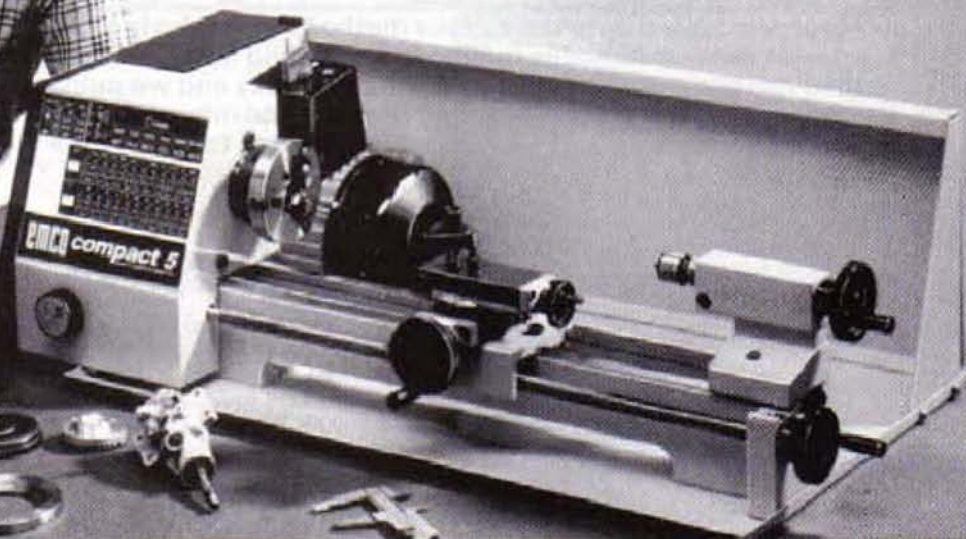
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# USING EDGE FINDERS

In this article we indicate the various methods of employing the wiggler for component edge finding in the milling machine. Each method has been tested to determine its accuracy and we publish the findings (which make interesting reading) and information which will enable you to determine which method to adopt for a given application

**T**he method used for locating the workpiece relative to the cutting tool will vary from one application to another and from one type of machine to another. We will all be conversant with the methods of locating the outside diameter of a part being turned in the lathe, by bringing the lathe tool slowly up to it and looking for the first sign of a mark on the outside diameter to indicate that the tool is just touching the workpiece.

Where the component cannot tolerate even the slightest mark on its surface, say when the surface is already finished and part of an exhibition assembly, then a thin piece of paper can be placed between tool and component and, with the machine stationary, the tool advanced until the paper becomes trapped. Following this procedure the tool can be moved to the area to be machined and cuts taken allowing for the thickness of the paper.

This is all quite straightforward and commonplace when working in the lathe but when a similar situation presents itself on, say, the milling machine, the problem is more difficult.

When the rotating cutter approaches the component it produces only a single line and this under the cutter itself, which can be difficult to see even in a good position. If the test has to be carried out at the rear of the part, then it can be almost impossible to see if not also extremely dangerous, and in any case this presupposes that we can accept a mark being made on the part at the point being tested.

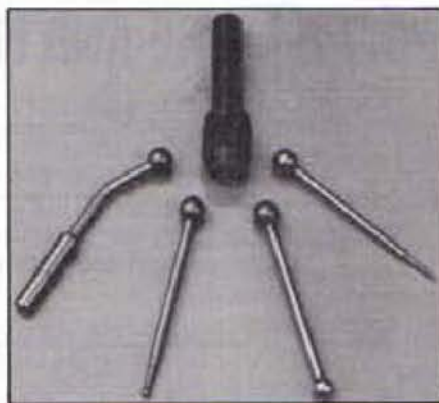
An alternative method would be a variation to that using paper on the lathe. In this case a piece of paper is placed between the cutter and the workpiece and it is then advanced until the paper becomes trapped. This of course is done with the cutter stationary; if the cutter is not long enough to reach the face being tested, say in the case of a stepped part, a length of round bar would have to be inserted in the chuck and used.

Whilst this method is probably adequate, in some cases it does have its drawbacks. If the test piece or cutter is not running true, then an error will result, the extent of which will depend on whether the test is being carried out on the high point or the low point or any position in between.

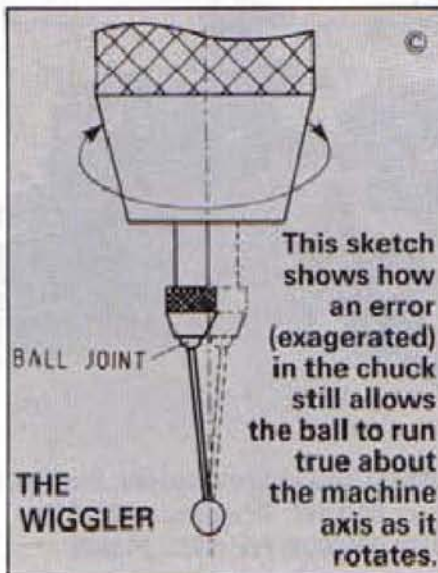
## Edge finders

This error can ingeniously be overcome by the use of an edge finder which are generally available in two forms. In this article we discuss in detail the type normally known as a 'Wiggler' whilst an alternative edge finder will be referred to later.

The wiggler works on the principle of a ball mounted on the end of an arm used to feel the side of the component to be machined. It also has a ball joint at the upper end mounted in the cutter chuck and this ball joint allows the lower ball to run perfectly true no matter how inaccurate the cutter chuck happens to be (see sketch).



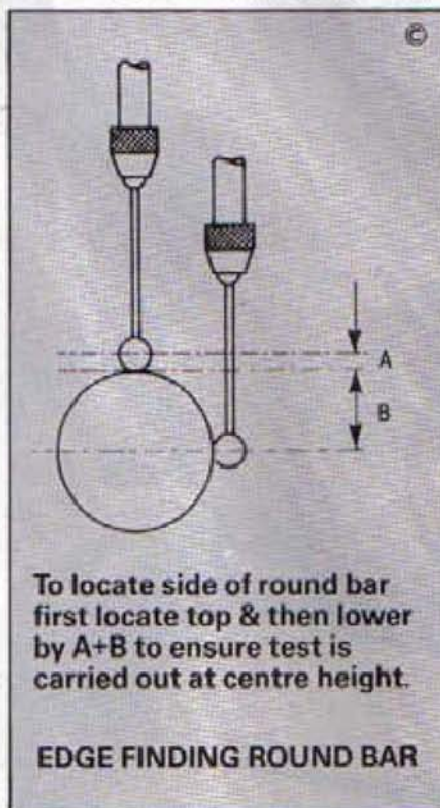
Above, the edge-finding kit.



## Recommended method of use

The recommended method for using this device is as follows: the Wiggler kit normally contains alternative parts for differing applications, at this stage the feeler with a 0.250in. diameter ball at the end is being considered.

With the part to be machined positioned



on the milling machine and the edge finder in place, the ball is lightly coated with engineer's blue and the machine started. As the ball at this stage is unlikely to be running true it will be seen to rotate forming a circle at the end.

The ball can now be made to run near true by placing a piece of wood lightly against the shaft, until the ball is running as near true as can be detected by eye.

The workpiece is now made to approach the ball and the condition of the blue on the ball observed. As the ball was probably not made to run perfectly true it will contact on one side only at first and remove the blue at this point only.

As the workpiece is moved further and the ball becomes nearer concentric with the machine spindle, the ball will be wiped clean round its complete circumference and will appear as a bright line. At this point it can be considered that the machine spindle is half the diameter of the ball away from the edge of the part to be machined, that is 0.125 inch.

This process would sometimes need to be repeated for the other axis. Having now located the work relative to the machine spindle, machining can commence using the feedscrew dials to achieve the required dimensions.

## Use on round bar

When being used to position round bar, the procedure differs in that a test is first required to be carried out to locate the top of the bar. The purpose of this is to then lower the ball by half the diameter of the bar plus half the diameter of the ball so as to ensure that the test on the side of the bar is carried out at exactly mid-bar height.



First mark the top of the bar evenly with engineer's blue and, with the ball running reasonably truly, move the bar backwards and forwards at the same time lowering the ball until the ball is just seen to be wiping the top surface of the bar.

The ball can now be lowered to bar centre height as indicated above, and tested on the side of the bar in the same manner as indicated for rectangular components.

### Alternative methods

Two alternative methods can be adopted and to judge the merits of these, comparative tests were carried out. The advantage of these two methods is that they do not require the use of engineer's blue, but this would be of little consequence if the end result showed errors greater than can be tolerated.

#### Alternative method 1

In the first method the work is advanced towards the ball whilst it is being run with a noticeable error. As the ball is forced closer to the true position by the advancing workpiece traverse can stop at the point that the ball appears to have become perfectly concentric. This could be considered to be the desired position.

#### Alternative method 2

The other alternative is really an extension of the first. If traverse is continued in effect forcing the ball past its true running position, it will suddenly spring out of position and swing considerably. This is going to be past the true position, but as the friction of the ball on the surface being tested will tend to make the ball run along the surface and run out earlier, perhaps the error may not be that much.

### Test method

The only way to test the accuracy of the three methods would be to test on opposing surfaces of known distance apart.

Unfortunately, as this would require tests to be carried out in both directions, the leadscrew dials would not suffice due to the error that would result in view of the backlash present. Some other form of measuring movement would be required and a method using a dial gauge was set up as indicated in the photographs.

### Testing for consistency

The first test was to check for consistency. This was to see if there would be any errors due to variations in choosing the point at which the blue was wiped clean around the full circumference of the ball in the first method, or for the ball to become completely concentric in the second.

To test for consistency the same test was carried out repeatedly, only referring to the dial gauge to determine the deviation after the test had been completed by the normal method.

Testing first with the blue it was found that a total variation of two thou was detected and the dial gauge set so that this indicated as plus or minus one thou. A few more tests were carried out to confirm this position and found satisfactory.

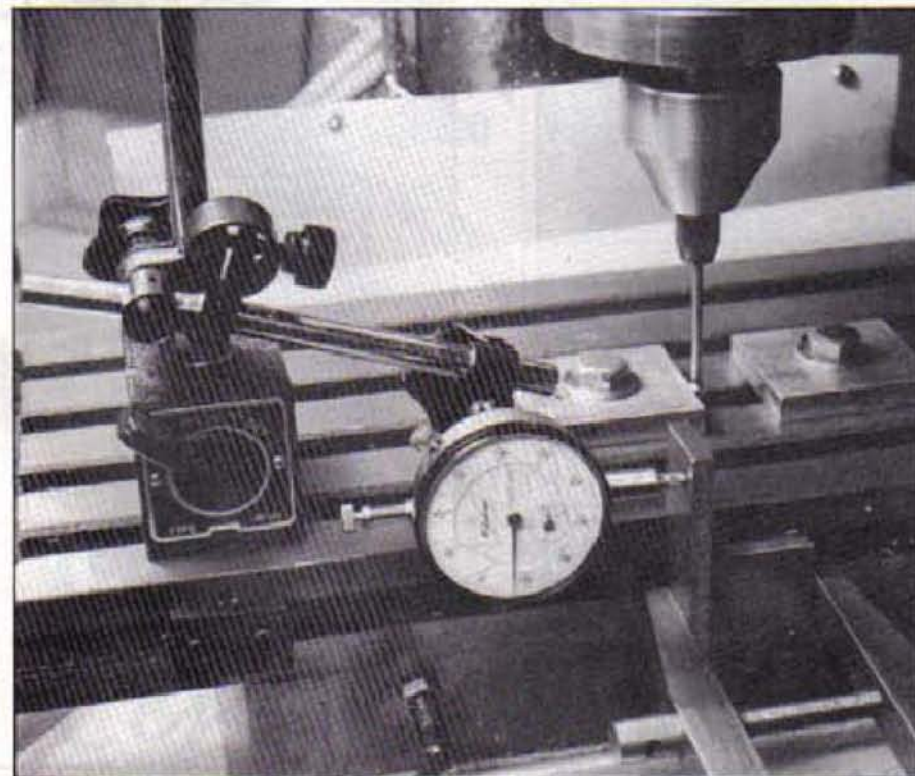
A similar test was now carried out but this time looking for concentricity; the tests revealed a variation still about the same mean but now plus and minus two thou.

This was followed by checking at which point the arm springs out of position; this was found to be very consistent at three thou past the mean found in the previous two tests, though it is considered that this could differ considerably from application to application, depending on the friction in the upper ball joint (a point which could have been tested but was not) and also the state of the surface being tested.

### Testing for accuracy

Whilst these tests indicate the

*The set-up for testing accuracy of the edge-finder.*



consistency of the three methods they in no way are a measure of the accuracy that results from their use. To do this it is necessary as indicated earlier to test between faces of known distances apart and in opposing directions; in this way any errors will be additive as opposed to cancelling each other out if tested in the same direction.

This test was carried out by the method using blue only as the comparative tests would indicate how the others would compare.

The two faces were set a known distance apart and the distance travelled between the two faces as determined by the edge finder measured by the dial gauge. After carrying out the test a number of times a mean value was established.

The value arrived at proved to be equal to the distance between the two faces but with a variation of plus and minus two thou. This variation ties up with the findings in the previous test which gave plus and minus one thou for a single face.

From these tests it can be seen that it should be possible to detect the face to within one thou — a very acceptable result, though by adopting the method without blue, accuracy should still be within two thou, sufficiently accurate for most applications.

The third method is really of academic interest only, having no practical use.

### Additional attachments

The wiggler set also has additional attachments and two are worth mentioning. The tests as carried out above were done as indicated with a 0.250in. ball and this would be used for most applications.

In a few cases where access is limited a smaller end may be required and for this a 0.100in. diameter end would be provided.

### The needle point

Additionally, an attachment with a needle point end will be provided, the purpose of this is to locate scribed datum lines on the workpiece, to do this the needle point is first made to run concentrically by gently applying pressure to the side of the shaft whilst the machine is rotating, when true the machine can be stopped and with the point very close to the face being tested the workpiece is moved until the mark on the part and the needle point line up.

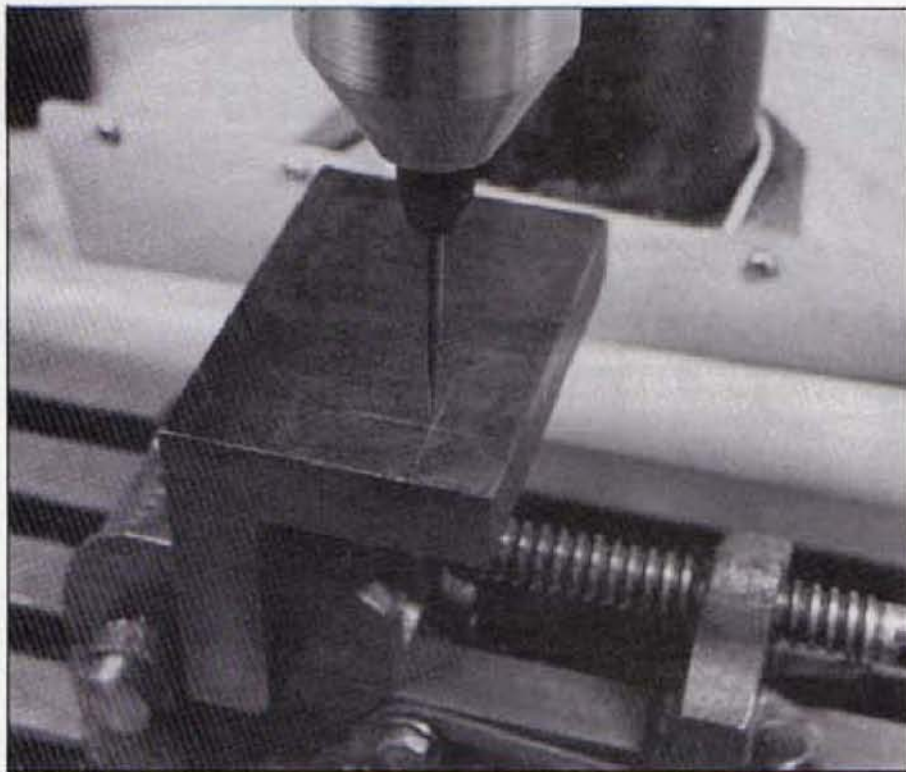
The accuracy of this process is of course not likely to be better than a few thou and other methods such as the use of toolmaker's buttons should be adopted for greater accuracy. (The subject of another short article soon, Ed).

### QUICK TIP

Most manufacturers of bench vices use standard material for their vice jaws which makes it a very simple operation to replace the existing jaws with a pair that extend, say, 1in. to one side — whichever side is your choice. Materials could be bright mild steel or gauge plate but hardening is not recommended.

You will find this modification most useful when folding small items, etc. Provided the fixing holes are tapped through, the jaws can then be reversed should any bending occur. E. R. Whiffin





Using the point to position onto scribed lines.

#### An alternative edge finder

An alternative form of edge finder is also shown in sketch form, this has a small disc mounted on the end of a shaft fitted in the machine chuck, the disc being arranged so that it can either take up a concentric or

a variably eccentric position.

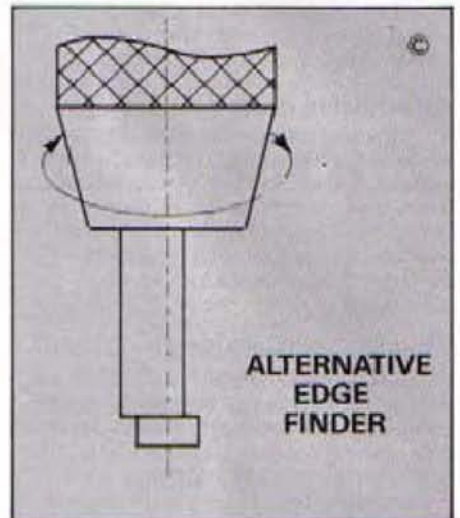
The method of using this device is generally as mentioned above, the disc becoming nearer concentric as the workpiece approaches it, and similarly as the disc is forced past concentric it will

swing rapidly to one side.

As no example of this type was available it was not possible to carry out tests, but it is anticipated that comparable results would be achieved.

One supplier of this device recommends adopting the method of waiting for the disc to swing to one side, and considers that if the test is carried out more than once to confirm the position, a consistency of 0.0002in. can be expected. This refers to consistency only and may also have an error factor as mentioned in the tests carried out as above.

This type is normally sold as individual items and not as sets but examples are also available with different diameter ends and also pointed for centre finding.



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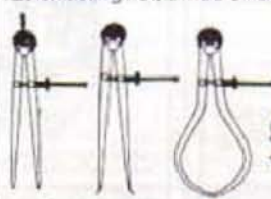
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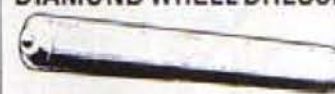
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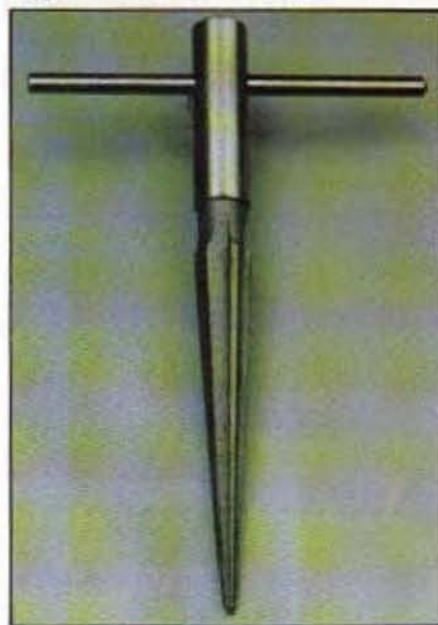
# TRADE COUNTER

This time we find a useful reamer, test a super little drawing board, look at some new saw blades and admire Emco's mouthwatering new Machining Centre

## TANDY TAPER REAMER

Spotted in the Tandy catalogue (Cat No. 64-815) a hand taper reamer of the type used for opening out holes in sheet metal, of particular interest to the electronic constructor with limited machining facilities (which is, no doubt, the reason it is found in the Tandy catalogue) but of equal interest to the model engineer.

The main reason for the interest in this item was the price. At £3.99 it was less than half the price of the cheapest we had seen and much less than half for the majority. The reamer covers the range of 3mm to 13mm and has a cross bar handle. One has been obtained and tested and appears totally adequate for use in the home workshop. For those to whom Tandy is unknown, they are a high street electronics supplier with over 500 outlets.



## COMPACT DRAFTER

We have received for review a version of the Viola Plastics Compact Drafter; made in a number of versions, the one tested was the A4 Deluxe.

I have no doubt that we all at some time (if not most times) made for the workshop with the intent of making some item of equipment to our own design, but without a firm idea as to how the design is likely to shape up. How much easier we find it if we have given it some prior thought and provided some ideas on paper before starting.

This little drawing board will help to put this situation to rights. In the form received it comes as a folder which, when folded, is rather like a normal A4 ring binder but not so thick. The simple pantograph arrangement comes with two scales both calibrated imperial and metric, and these can be reversed so that the required calibration imperial or metric is available for

use, the protractor head is calibrated in five degree steps and can be rotated through a full 180 degrees.

The pantograph was found to produce adequately parallel lines and would cover the whole of the A4 sheet except that the paperholding clip could be a problem near the top of the page, though there are numerous ways round this situation. There



is not doubt that these are capable of producing with ease, acceptable drawings for the home workshop enthusiast.

The unit includes a very adequate spring clip at the top of the A4 sheet for holding the paper, also a clip for holding the two pencils supplied, and a small drawer housing the pencil sharpener and rubber also included. It is well finished and, when folded, is easily transportable, even for that away-from-the-workshop assignment. If I had to try and find some fault, it would be that the two pencils were both grade HB, I feel one HB and one 2H would be better for the type of drawing these Compact Drafters are intended for.

At £15.80 inc. p&p and VAT they seem good value for money and even more so the A3 Desk Pad model (that is not foldable) at £20.15 inc. p&p and VAT. Also available is Desk Pad A4 version, in landscape format ie paper lengthwise rather than upright, this at £14.80 inc. p&p and vat. For further details and confirmation of latest prices, contact Viola Plastics, 36 Croft Road, Hastings, Sussex TN34 3HE. Tel: 0424 432126.

One of these little drafters will enable you to design your next project in the comfort of your lounge, and maybe the drawings can become the starter for an article to be published in *Model Engineers' Workshop*. How about it?

## STARRETT BLADES

Ranges of Starrett jigsaw and reciprocating saw blades are now available through distributors and DIY outlets. The L. S. Starrett Company of Jedburgh, Scotland TD8 6LR (Tel: 0835 63501) is a major manufacturer of bandsaw, and

hacksaw blades as well as holesaws used in many industries and by DIY enthusiasts.

Starrett's new jig and reciprocating saw blades, made to the same precision and high standards as these other saw products, produce exceptionally straight cuts and give long life.

Produced in two different types of steel - high speed steel and high carbon steel - the jigsaw blades have a variety of shank designs to fit most popular makes of jigsaw machine; the reciprocating saw blades are of bimetal construction and have a universal shank design.

## Jigsaw blades

Starrett's high carbon steel jigsaw blades, for cutting plastic, wood, plywood, chipboard and blockboard, are made with 6, 8 and 10 teeth per inch (tpi) with Bosch, Makita and universal shank designs. High carbon steel jigsaw blades with ground sides are also produced, with a tapered side relief preventing the blade from binding and giving a particularly smooth finish on the cut faces.

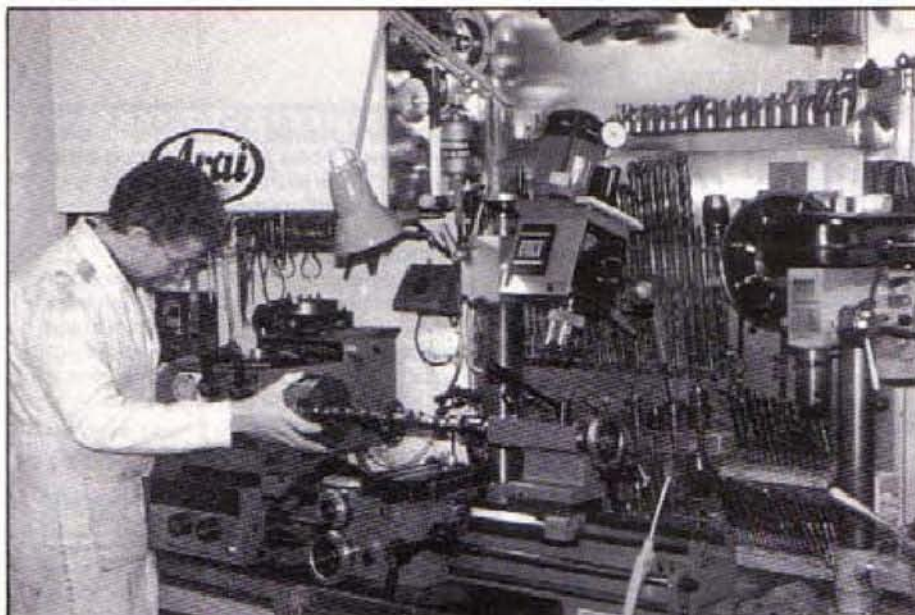
High speed steel jigsaw blades, in 8, 10, 24 and 32 tpi sizes, are designed for cutting metals, plastics, wood, laminated plastics and GRP, electrician's conduit and tubing.

## Reciprocating saw blades

Starrett reciprocating saw blades are all bimetal in construction, having a high speed steel cutting edge on a flexible back to make the blades tough, shock absorbing and virtually unbreakable. Available with 6, 10, 14, 18 and 24 tpi, all sizes have a universal shank design and will cut almost all types of wood, metal, plaster and plastic.







## EMCO'S NEW MAXIMAT SUPER II

The Maximat Super II is a highly versatile machining centre developed by Emco Maier to extend multi-functional working. For this manually operated machine enables turning, universal milling and drilling operations to be carried out on the same components in a single set-up.

Such versatility makes the Super II equally at home in the CDT laboratory or in the workshop of a serious modelmaker. And to meet the varied requirements of such users, the machine is constructed around a system of building blocks which can be purchased separately (as and when required). This enables the basic turning machine to be expanded into a universal

machining centre with the addition of the vertical milling/drilling unit, machine stand and the splashguard.

Built to DIN 8606 and Schlesinger No II standards, the Super II is a precision machine tool which features a fully geared headstock (with shaved gears running in an oil bath for quieter operation), large vee-guideways, a rigid main spindle and quick spindle speed changes. Safety has been a prime requirement in the design of the machine - all drive and power transmission elements are totally enclosed and a number of slipping clutches and special feed locks are incorporated. However, for the education sector, there's also a 'special safety' version which features ultra-safe cut-out relays and additional

microswitches.

In terms of capacity, the machine has a swing over the bed of 280 mm and a distance between centres of 650 mm. Power is derived from a 14 kW motor which provides eight spindle speeds in the range from 55 to 2200 rev/min. Saddle is powered by a leadscrew for screwcutting or by the feed shaft for profile turning. The basic machine comes as standard with a tailstock, centres, single toolpost, a set of wrenches and an instruction book. Single phase or three phase motors can be specified.

The addition of the universal milling/drilling unit (which locates on the rear side of the bed) transforms the basic lathe into a fully-fledged machining centre. Powered by its own 0.3 kW motor, the fully geared vertical head provides six speeds going from 120 to 2000 rev/min. This head can be swivelled up to 360 deg. (for full five-sided machining) and traversed up or down the circular support column. Maximum height between the table (cross slide) and spindle is 305 mm. The quill has a stroke of 40 mm.

All the controls, on both the lathe and the milling attachment, have been ergonomically designed for ease of operation and safety.

A comprehensive range of accessories is available for the Super II. In addition to all the usual extras (chucks, collets, coolant pump, tooling etc), Emco also offers: toolpost grinder, milling table, machine vice, fly cutter, dividing head, angle plates and various slotting accessories. For more information, contact: Emco Maier Ltd, 10 Woodshots Meadow, Croyley Centre, Watford, Herts WD1 8YZ. Tel: 0923 50051.



## CUTTING REMARKS

Never let it be said that this new editor is not prepared to publish comments from people who disagree with aspects of his work! **Ascanio Giannuzzi** from Milstead, Kent makes the following points with regard to the Milling Cutter Chuck article in our June/July 1991 issue.

I find Point 2 a very interesting idea and one I will certainly take on board. With regard to Point 3 I have some reservations (maybe it's my old lathe, very much abused by its previous industrial owners). Has any reader any observations to add? Many thanks for the letter and compliments also Ascanio.

I refer to the article Milling Cutter Chuck in your June/July issue. I think Mr Hall has produced a very fine and interesting piece of equipment but I would like to be allowed to disagree on a few points.

1. I feel collets could be better machined at one setting ensuring absolute concentricity of all machined parts. I would chuck a piece of say  $\frac{1}{2}$  in dia. steel protruding the length of the collet plus a small amount for parting the finished article. Drill the length of the collet plus say  $\frac{1}{8}$  in with the tapping size drill for the thread which could be done with the aid of a tailstock tapping device to ensure a straight job; then bore away the rest to size leaving the thread  $\frac{1}{8}$  in long as per drawing. Starting from the back as suggested, one would have to drill more than the  $\frac{1}{8}$  in required to be able to thread to length and this could create problems when boring from the front side. The outside part of the collet would be a simple job without the need for a mandrel for each collet to be made.

# SCRIBE A LINE

**Your views, your pages! Your opportunity to make your point, ask the question or simply pass on a snippet of interesting advice to others. Your letters for publication in Model Engineers' Workshop are always welcome**

2. To match the taper of the collets to that of the outer ring without moving the top-slide and without reversing the lathe I would use a tool upside-down and machine the taper part of the collets from the back; this would ensure perfect fitting and avoid a laborious 'blueing' of yet another extra part.

3. I cannot agree on the use of round nose tools for better finish which in my opinion is only apparent but not real. A properly and correctly ground tool with a sharp point and a minute radius honed on it will respond much better to fine and precise cutting and with correct speed and a touch of cutting oil produce a superb finish.

Regarding machining of the body, if permitted, I would like to add one thing: if one has the same size taper in both mill and lathe then the obvious way to do it is to machine taper and thread for draw bar and then remove the chuck and place the part directly in the taper of the lathe mandrel and proceed with the rest as in the article. This will produce perfect concentricity when in use.

## BASIC PHYSICS

Mr S. J. Price posed the question, **Mr K. Hamer** of Colne, Lancs offers an answer.

Mr S. J. Price from East Finchley (Scribe a Line June/July 1991) asks why a hosepipe



seems to have less kick when placed in a watering can.

The reason is this. The thrust of a hose pipe, like that of a jet engine or a rocket, is dependent on the amount of fluid flowing through, and the speed it leaves the jet. The lower the pressure outside, the greater will be the jet speed. Rockets work best in space where pressure is zero; so would a hose pipe.

If the exhaust pipe of a car were to be placed in water, it would reduce its speed; if placed in a tank with low pressure, it would increase speed. Many people think of a jet engine (or a hose pipe) works by pushing on the air outside. They don't, as a rocket in deep space proves the point. Hero's turbine would benefit by running in space...

Another reply to this question was received from Chris Dyos of Dartford Kent. This is a lengthy and scientific version of the above, complete with formulae and diagrams and, as suggested by Chris, has been sent direct to Mr Price, anyone who would like a copy should send a stamped addressed

envelope marked 'SAL Hose Pipe'! But Chris Dyos also poses his own question relating to another letter:

I enclose an answer to Mr S. J. Price concerning the serpentine behaviour of his hose. I am afraid it will want a lot of editing before it is fit to print, you may prefer to send it to him as it is.

Incidentally, reading the next letter in the June/July issue I notice that Don Macmillan considers that in the model of Hero's steam turbine that the water is "driven up the hot sides by centrifugal force". Tut tut!

Firstly, there is no such thing as "centrifugal force". The sides of the can exert a force inwards on the water to keep it moving in a circle, otherwise it would keep going in a straight line in the direction it happened to be travelling at the time, as happens when a hammer thrower lets go of the hammer.

Secondly, if there was such a thing as centrifugal force it would act outwards from the centre against the walls of the can.

How can such a force drive the water upwards?

It is a well-known fact that, if a cylinder of liquid is spun about on its axis, the surface of the liquid assumes a parabolic shape, but the explanation of why this happens is far from clear - to me at any rate. Maybe one of your learned readers can elucidate...

## WAVY WASHERS

Mr Stephenson of Keswick has written asking for help in obtaining some items for a project from the June/July 1991 issue.

Your Model Engineers' Workshop magazine is a winner. I have bought the June/July issue and have made two pieces from this edition - the Travelling Steady and the Drilling Machine Depth Gauge by D. O. Coe. Please let me know where he managed to purchase the internal circlip and the wavy washer. I cannot get these here and would be very grateful for any information.

Mr Coe has made the following suggestion re. the wavy washer but is unable to suggest a supplier for the circlip, can any reader come up with a supplier for circlips in small quantities? Wavy washers can be obtained from: Spring Masters Ltd, Arthur St. Lakeside, Redditch, Worcs B98 8 LF. They do have a minimum order charge of £5 - quite reasonable for a supplier to industry.

## ML7 GEARBOX

Mr F. J. Robinson of Coventry writes explaining how he has adapted the design for the ML7 gearbox in the Winter '91 edition to suit his earlier Myford ML2, and has found a couple of errors on the way.

I would like to congratulate you and your magazine for publishing the excellent article by Mr Alan Buttolph on "A Gearbox for the ML7" in the winter edition. Because of its small size I found that I could fit one to the earlier series of Myford lathes, and have successfully completed one for my ML2. In fact it needed very little alteration.

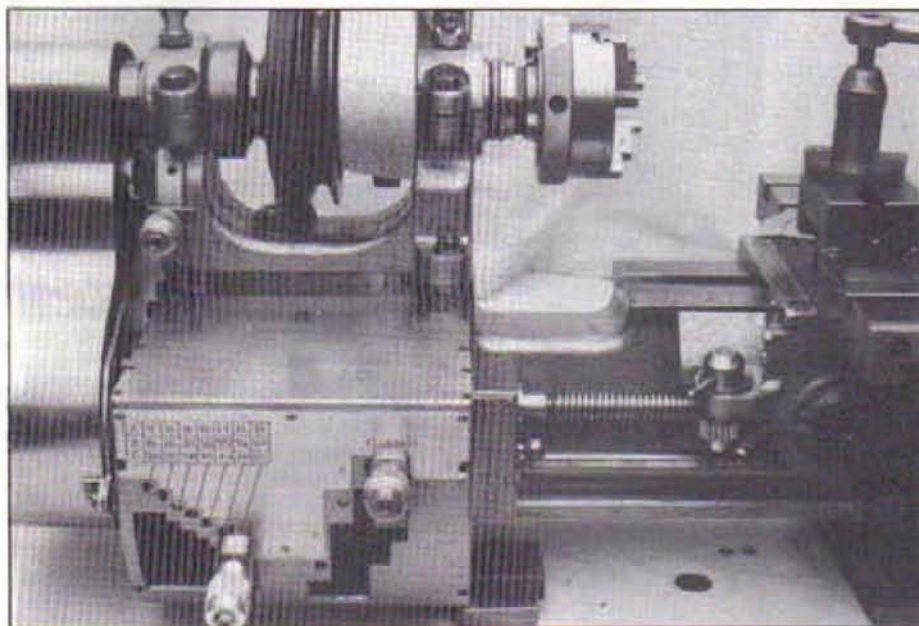
The LH end plate (ref 1) was shaped to fit the end of the smaller bed. The length of the gearbox is exactly the same as the length of the headstock, so the left-hand foot used for mounting the lathe to the bench is now covered up, as you will see in the photograph.

The lathe had previously been fitted with mild steel strips to extend the width of the feet, and it now needed a plate screwing to the left-hand front strip to extend this sideways towards the tailstock, the bottom plate of the gearbox being cut away to fit around this. Apart from this, the box is exactly as described by Mr Buttolph.

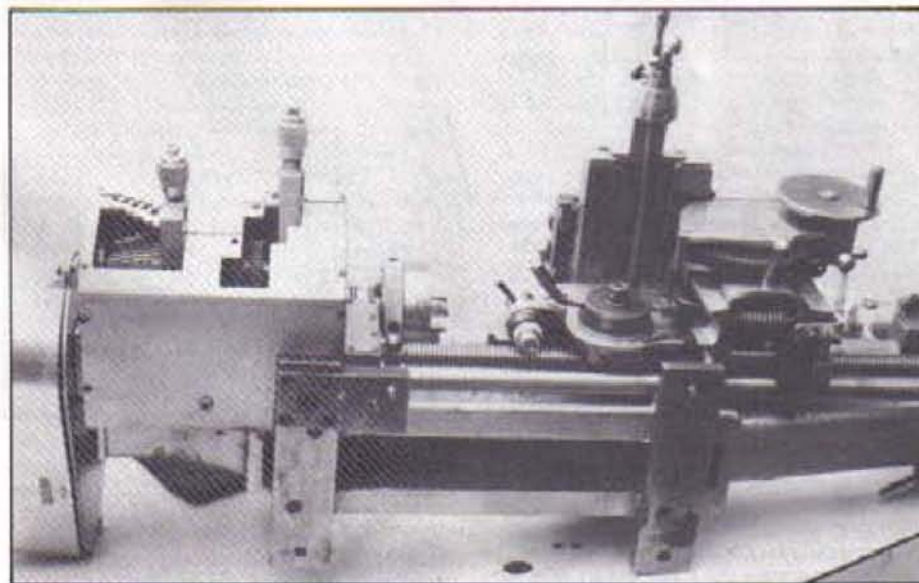
The lathe has been extensively modified over the years; it was purchased from a Coventry ironmonger in August 1940 for the price then of £8.8.0! Three months later the shop was destroyed in the Coventry blitz.

I would like to point out two errors in the original article. They were: The overall length of the gear change lever (refs 18 & 19 was incorrect, the figure quoted (4 inches) should have been to the centre of the radius and not to the outside, making the new dimension 5 inches.

Also on the table of gears, one of the 20 tooth gears should have been 0.500 inch bore for a press fit on to ref 28, and not 0.375 inch bore as quoted.



Above and below: Two views of the gearbox made by Fred Robinson, modified from that published by A. Buttolph. Note how neatly the gearbox fits to the Myford ML2 lathe and in the underneath view how the base of the gearbox has been cut to accommodate the modified fixing feet.





## PUMP PROPOSITIONS

David Webster of Williamstown, Rhondda makes some observations on the recent article on coolant pumps in the June/July '91 issue and offers a few suggestions of his own.

Your article on a coolant pump based around the use of an automobile mechanical petrol pump was very interesting, as I have two coolant pumps that use BMC Mini electric fuel pumps, one fitted to a Grayson lathe, the other to a horizontal/vertical bandsaw. Both are powered by a 6 amp battery charger.

Although they work well, the coolant flow is of a pulsating nature and this would also be the case with the mechanical fuel pump. I have found the pulsating flow of the coolant to be a nuisance and a constant flow is much preferred. (Fig. 1)

valve as used on household plumbing systems would be suitable although a little cumbersome. (Fig. 3)

The reasons I chose to use an electrical fuel pump were that I feel that it would be a nuisance to have to keep oiling the cam and pump lever on a mechanical pump unit and of course the electrics are a lot safer being 12V DC as opposed to 240V AC.

I have since moved on to some larger equipment and have had to make a coolant pump with a much larger flow capacity. The way I achieved this was to use a combination of the unit in your article, not using a mechanical fuel pump but by utilising an automobile oil pump as used on all BMC types (mine was based on a Maxi pump). This system gives a maximum of 48 l.p.m. using a 150 watt motor and pump speed of 400 r.p.m.

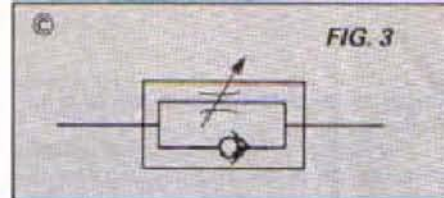


FIG. 3

There has been no requirement for a bypass valve on my unit and I put this down to the fact that coolant is so much less viscous than oil, and as I have used an old pump the internal clearances are such that my unit when restricted to give little coolant flow actually regurgitates and therefore does not overload the motor. A bypass valve would work as shown in the sketch. The unit has worked well for some 80 hours continuously and has not needed any attention. (Fig. 5)

Unlike fuel pumps, oil pumps provide a steady flow of coolant and the only need for a flow control valve (tap) is to modify the quantity of coolant delivered to the work. The accumulator as fitted to the fuel pump is self-pressurising providing the lid is properly sealed. Another method of smoothing coolant flow from a fuel pump is to pump coolant up to a cistern above the machine and have a gravity-fed coolant supply to the work. (Fig. 6)

## BE WARNED!

From Blackwater in Surrey, Mr E. Whiffin offers these words of warning.

Congratulations are due to MEW for a marvellous article of the lathe clutch which was directed to the ML7 and was suggested that it could be adapted to any lathe with a countershaft. My main lathe is a 4, in Boxford with a rear countershaft and if this clutch was fitted as drawn then operating the clutch lever would entail reaching dangerously over the rotating lathe chuck. I have overcome this problem by extending, by 10 inches within an aluminium tube, the operating mechanism.

Still wearing my Safety Officer's hat I must also comment on the dangerous antics of New Zealander Bill Morris when machining the circular slot shown in his cross slide article. The gloves shown would only keep his hands clean and offer no protection should a sudden grab occur.

Having spent five years in New Zealand, I do understand their pioneering spirit but

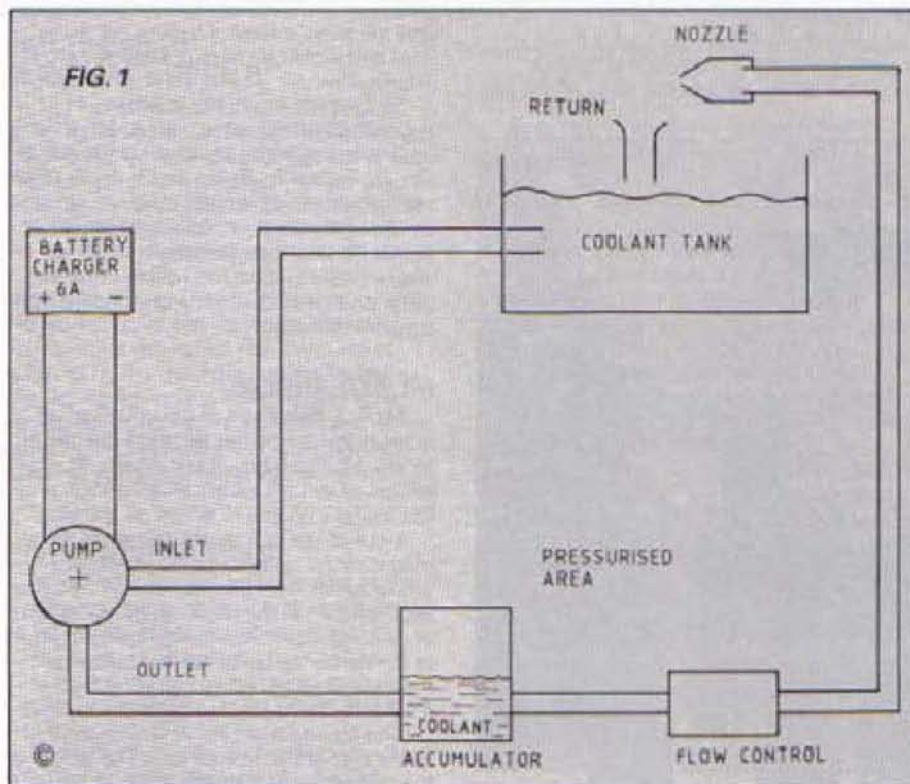


FIG. 1

To get around this problem I fitted an accumulator between the pump output and the exit nozzle, plus a restrictor fitted between the accumulator and the nozzle, which could be used to both alter flow and pressurise accumulator to give a lesser but steady flow of coolant. This modified system works well and would be a good modification to carry out on the mechanical unit of your previous article. (Fig. 2)

The accumulator was made from a plastic bottle of approximately one litre capacity and the inlet/outlet connections were made as shown. The plastic jar used has a large lid which made assembly easy. The restrictor valve was of an airline type adjustable clack valve as shown and this was used as it had suitable connectors for materials at hand, and was a nice compact unit. Any flow control valve would do; a ball

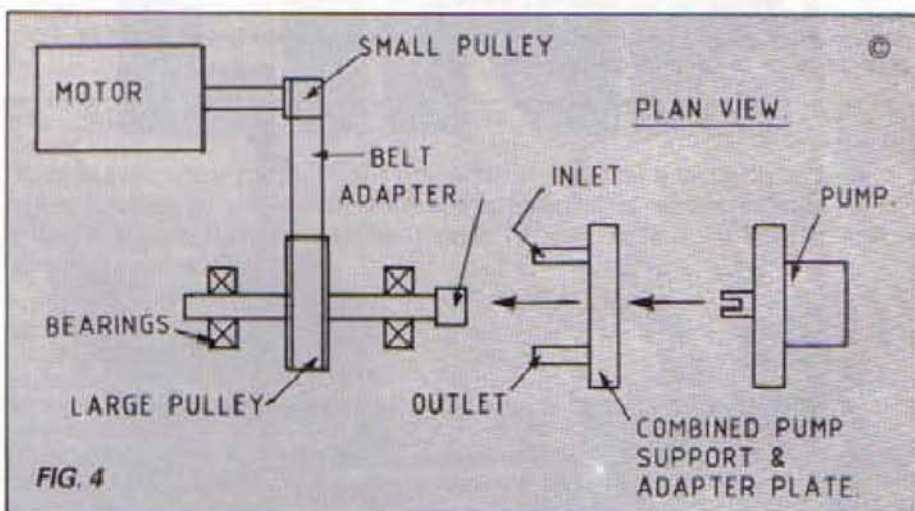


FIG. 4

Greater or lesser volumes can be achieved using different pump revolutions although it is advisable that to increase pumping above 600 r.p.m. a slightly larger motor would be necessary, say 180 watt. The sketch shows the basic layout. (Fig. 4)

Bill must realize that even the smallest model engineering machine can still bite. Please heed my words as I have seen machining accidents too horrendous for this publication!

Still with safety in mind, I notice that

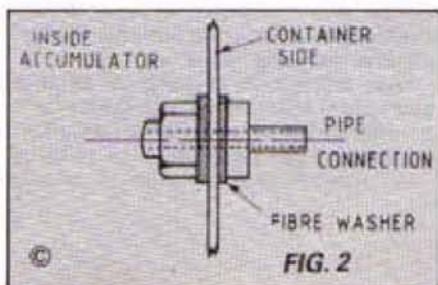


FIG. 2



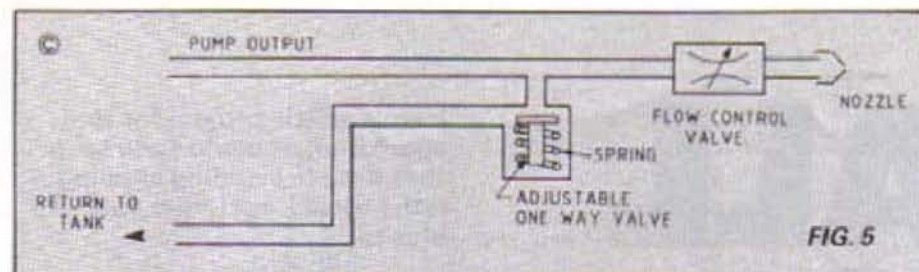


FIG. 5

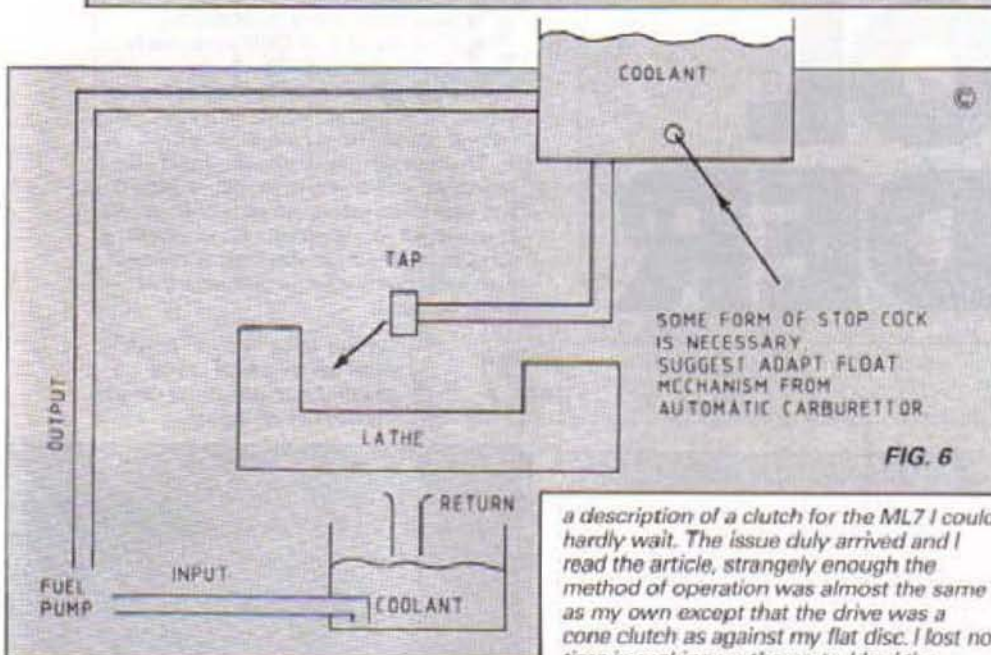


FIG. 6

**MEW** June/July issue 'Quick Tips' suggests the use of WD40 as a cutting lubricant. Although I have used WD40 for umpteen jobs including gun cleaning after black powder shooting, the use as a cutting lubricant could be disastrous as I have seen WD40 sprayed into a brush motor with an effect worthy of Guy Fawkes night - be warned!

## CLUTCHING AT STRAWS?

The article on the ML7 clutch (**MEW** June/July '91) was eagerly awaited by **Mr Birkinshaw** of Pentraeth, Anglesey but having made it he ran into problems. **Mr Buttolph's** reply is also published; does any reader have anything to add?

For some time now my wife has been complaining that when I am in my workshop and she is reading or knitting, every time I switch on my lathe the lights flicker, and as some projects need the lathe to be stopped and started a considerable number of times this can be annoying! About two years ago after wearing out a pulley due to throwing over the tension lever and allowing the belt to slip, I decided it was time that I had a clutch.

One article appeared in **Model Engineer** using an industrial sewing clutch, but this was rather bulky and in any case such things are not available in my area so I decided to design my own. I tried several ideas but none were really successful until the last one I tried using flat plate clutch similar to the type used on cars. First I tried metal to metal discs but this tended to slip on load, then I tried a metal disc with cork inserts as used on the old motorcycles but this also slipped on load. I did everything I could think of but could not overcome this problem. So I shelved the idea and went back to slipping the belt.

Imagine my intense pleasure when I read in your excellent magazine **MEW** that in the next issue there would be a plan and

a description of a clutch for the ML7 I could hardly wait. The issue duly arrived and I read the article, strangely enough the method of operation was almost the same as my own except that the drive was a cone clutch as against my flat disc. I lost no time in making up the parts. I had the pulley and the shaft but I decided to make a new shaft and as the design had obviously been tried out and worked I stuck strictly to the drawing.

I eventually finished all the parts and fitted them to the lathe and adjusted the clutch; I cannot think why I never thought of using a cone clutch. The big moment had now arrived, I switched on the motor and engaged the drive - nothing happened! The clutch must not be adjusted right. I adjusted the clutch. This time it worked but no way would it take the load. I tried every possible way to make it work but I am back to square one with the same fault I had with my own design.

I have treble checked all the measurements and all the possible adjustments and I always arrive back at the same conclusion that the spring pressure is not great enough. I have opened out the bore to take a spring twice as strong as the one suggested and I still think I need a stronger spring but space in the shaft will not permit it.

Can you or the author of the article suggest a cure? I have checked the mating surfaces and they match perfectly. The leather I have used is genuine leather supplied by a good neighbour who is a saddlemaker. I have adjusted the clutch in every possible way. Perhaps some of your readers have made this clutch; if so, what results have they had? If you can help I would be extremely grateful. May I congratulate you on a wonderful magazine and may it go from strength to strength.

May I venture to comment on the quick tip using jars with the lids screwed to the underside of shelves. Whilst the tip is a good one, it is one that could be a little dangerous. As an Auto Electrician for more years than I care to remember I used to use that method for storing various sizes of oilite bushes in oil, but I found that, with present manufacturing methods of cutting corners, a lot of jars do not have proper full

threads and do not always screw home correctly with the result that the jar falls onto something hard and breaks.

One final question please: in your pictures of engineers using machinery etc, how do they keep their hands so clean!

## ALAN BUTTOLPH REPLIES

**Mr Birkinshaw** has my full sympathy. He is not the only model engineer for whom things go wrong, for no logical reason, after due attention has been given to all the important and less important details of a promising project. As my own clutch has given me faultless service for some years now I am quite sure that **Mr Birkinshaw's** clutch will soon be doing the same for him.

As the clutch design is quite basic and kept free of all unnecessary refinements it is difficult to pinpoint any probable locations of trouble. Essentially, if the conical mating surfaces are mating truly, with reasonable axial pressure to maintain contact, then if one half of the clutch rotates the other half must go with it.

Dealing with the trite and obvious possibilities first: it is clear that the half-clutch fixed to the driving pulley must not 'back away' when the moving half attempts to engage it. In other words, the axial movement of the driving pulley must be the minimum possible - zero if you can ensure that no binding occurs. The movement of the moving half can be quite small, certainly no more than an eighth of an inch between full engagement and disengagement.

Having ensured full engagement, if slip still occurs, it will be essential to increase the friction between the mating surfaces. No grease or oil should appear on either surface and the leather surface should not be polished or shiny; if it is, go over it hard with a wire brush. An application of powdered resin will appreciably increase the 'grip'; this is available from a chemist or, failing that, music shops sell blocks of resin for violinists and this is easily ground for our use. The mating, metal, face can be quite smooth, even polished but, no oil!

The axial movement of the Push Rod must be quite free, so the rod can be quite a slack fit in the bore of the Countershaft.

I assume that there occurs no slippage of the cone pulley on the countershaft. The locking screws must be firmly tightened during assembly to keep the pulley solid with the shaft under power drive.

At the other end of the set-up, under the control lever, the Thrust-block must, of course, be rigidly held to the end of the countershaft bracket; any movement here neutralises engagement of the clutch. Ensure also that the Thrust Washer is firmly held to the countershaft as it has to resist the axial thrust tending to take the countershaft with it.

The shape of the Thrust-block is rather awkward but can be made, to working tolerances, with a little patience. The spring details given will provide adequate axial thrust and the provision for final axial adjustment is, again, quite adequate for the ML7 set-up.

I have to assume that the dimensions given have been adhered to so that the axial spacing on the countershaft is maintained. Any unwanted play here is detrimental to proper operation. As an aside, **Mr Birkinshaw** will have realised that the keyway at the clutch end of the countershaft is  $\frac{1}{8}$  inch deep, not wide as given.

Continued on page 36



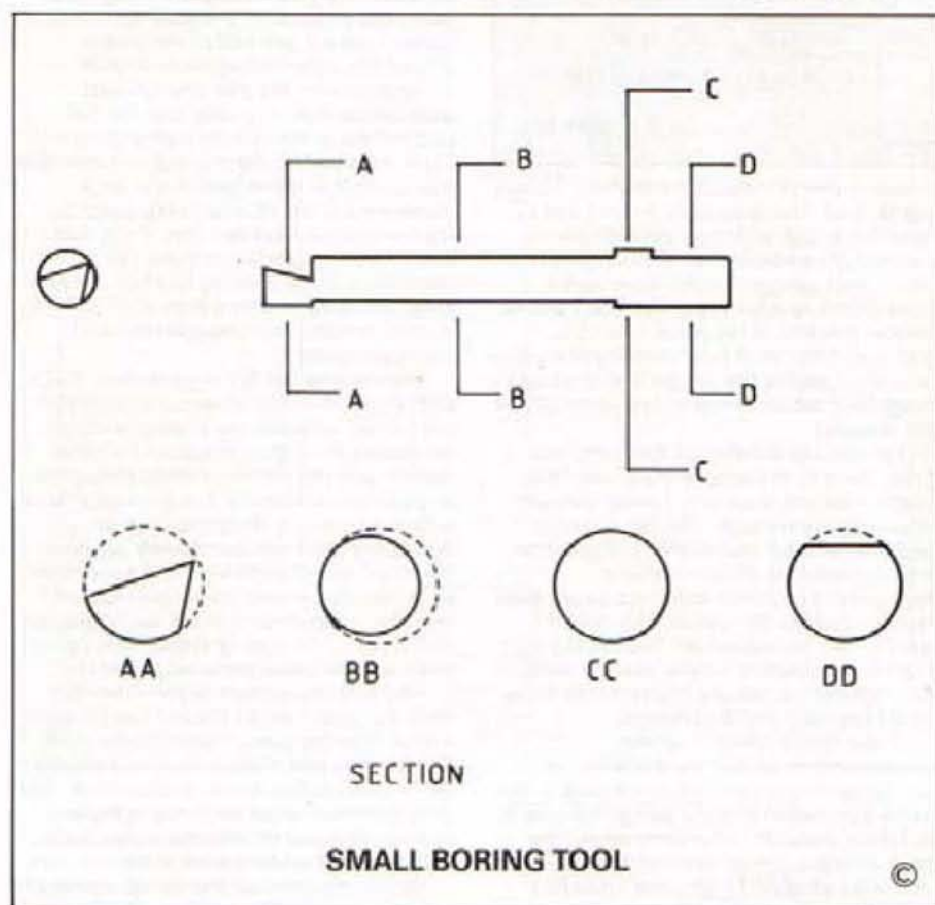
# SMALL TOOL HOLDER

Here's a little project for that spare hour; it could soon save that time in avoiding shaping lathe tools from larger tool blanks

Some readers will purchase the majority of their lathe tools ready-made whilst others will almost always grind them from high-speed steel blanks. However, all require to produce that one-off special from time to time.

This can be time-consuming and also expensive and one way to reduce both time and cost if the tool required is only small is to use small round toolstock mounted in a suitable holder. If  $\frac{1}{4}$  in. diameter is chosen then even broken centre drills size BS2 could be used!

*Below, both sizes of holder; note parting tool in the smaller one arranged for use in the rear tool post.*



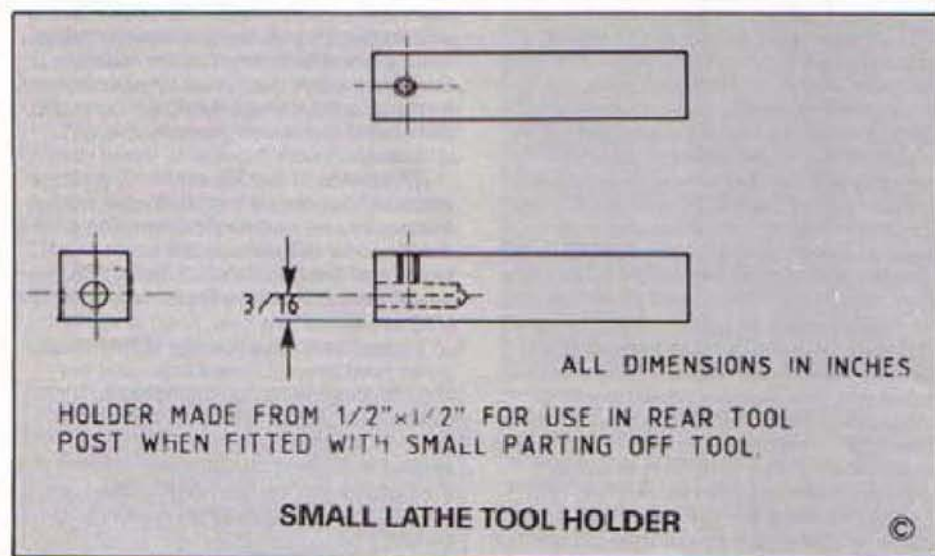
Construction really requires no explanation other than to point out that if the holder is centre drilled and drilled on the lathe as shown in the photograph, ensure a piece of  $\frac{1}{4}$  in. packing is placed below the material, so that the tool will not require to be ground to half its thickness to get down to lathe centre height.

When shaping the tool, first grind a flat on the round section where the fixing screw is to grip, then insert into the holder and tighten the fixing screw.

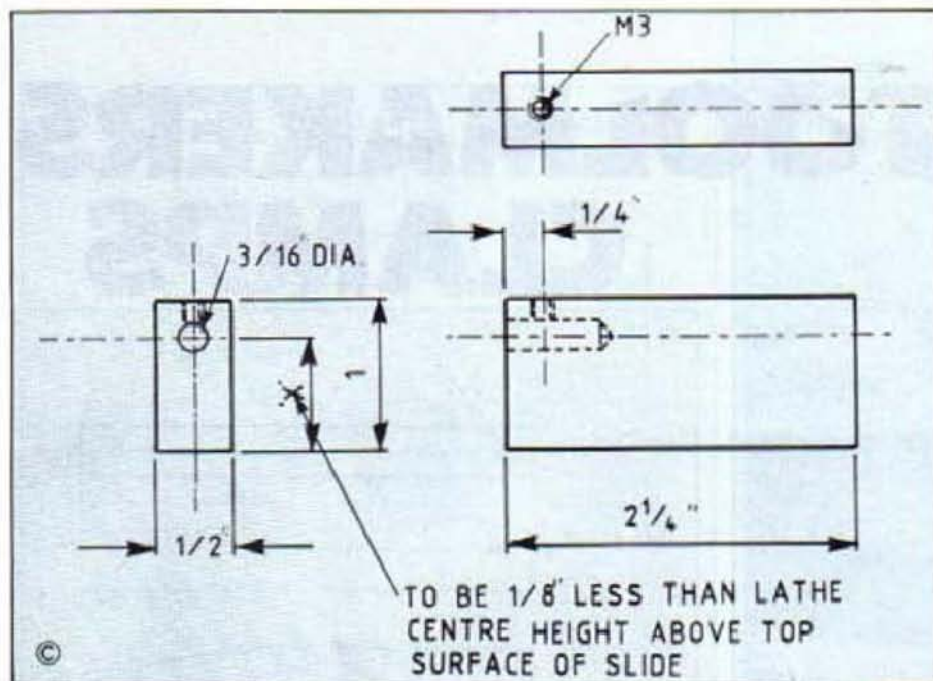
Other than the flat mentioned above, always carry out the grinding whilst the tool is in the holder, as this is both safer and it is much easier to judge the grinding angles using the square section as a reference. Do ensure the fixing screw is firmly tightened as it can easily be vibrated loose during the grinding operation.

Whilst this holder was initiated as a holder for that special tool, required on a once-only usage basis, it has been realized that it has other most beneficial uses.

Larger boring tools, say  $\frac{1}{2}$  in. diameter and over, can be in the form of a holder with a small tool steel bit, but for smaller sizes they require to be ground from the solid. For very small sizes this holder can be used and a tool ground as shown. [See article on lathe collets; this would be very useful to bore the smaller sizes of collets, even a  $\frac{1}{4}$  in. diameter holder would be beneficial for this. Ed].







If a holder is made using  $\frac{1}{2}$  in. square section then it can be used in the rear toolpost (or even the four-way toolpost) and fitted with a tool ground as a very small parting-off tool — very useful when making a large quantity of very small parts such as rivets, screws or nuts, etc.

To make this, place the material in a four-jaw chuck but held off centre, so that the drilled hole is positioned as indicated in the part drawing.

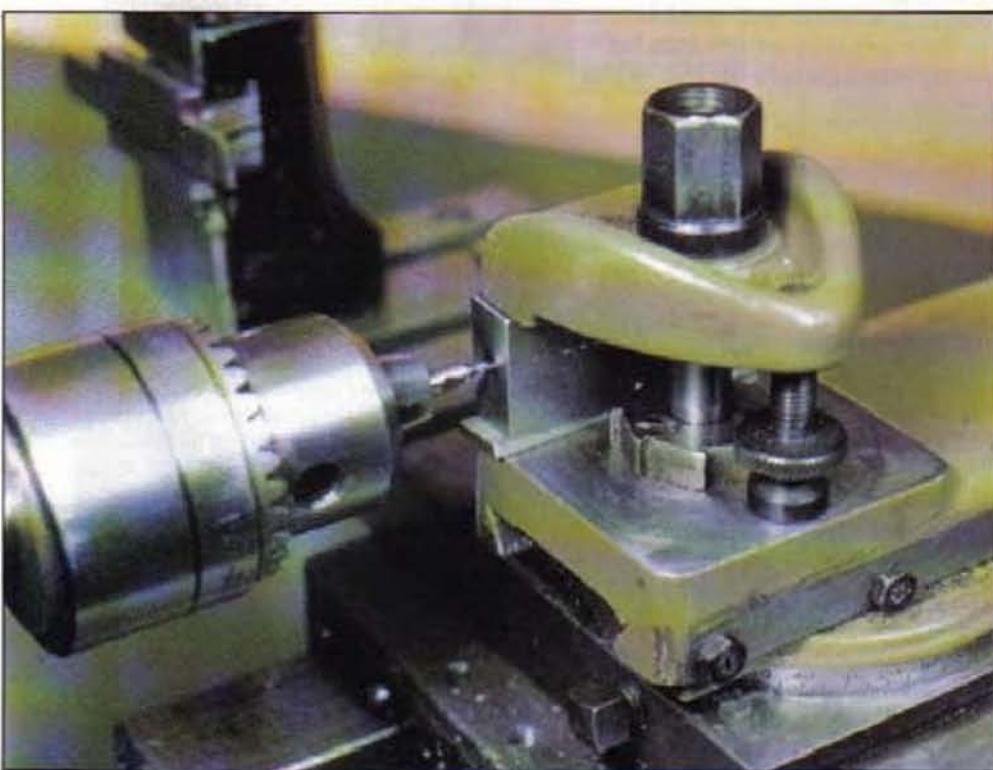
Similar holders could be made for other diameters larger or smaller. If the toolstock comes in pieces which are too long then carefully grind round the piece at the length required using the corner of the grindstone. If you are tempted to break it off after grinding part way through (you should not do this but I do know it is done), **PLEASE MAKE SURE** you grind to less than  $\frac{1}{8}$  diameter and then, after fixing in the vice with the reduced diameter portion in line with the end of the vice jaw, place a length of tube over the half to be broken off, **COVER THE VICE AND THE AREA TO**



Below, centering the end of the holder on the lathe; note the piece of packing which ensures the tool will not require to be ground to half its thickness.



Close-up of the finished holder complete with boring and parting off tools.



**BE BROKEN WITH A SUBSTANTIAL PIECE OF CLOTH** and lever.

As with most workshop operations, the wearing of safety specs would be a sensible added precaution.

These toolholders are so simple and quick to make that it is worth making a number from the start, ready to receive cutters as they are required.



## QUICK TIP

If you require occasionally to degrease metal components either prior to painting or when using adhesive for glueing metal parts together, a small bottle of typist's correction fluid thinners (trichloroethane) can be purchased at any good stationery store. It is sold in small bottles complete with application spout, which enables small amounts to be dispensed with ease.

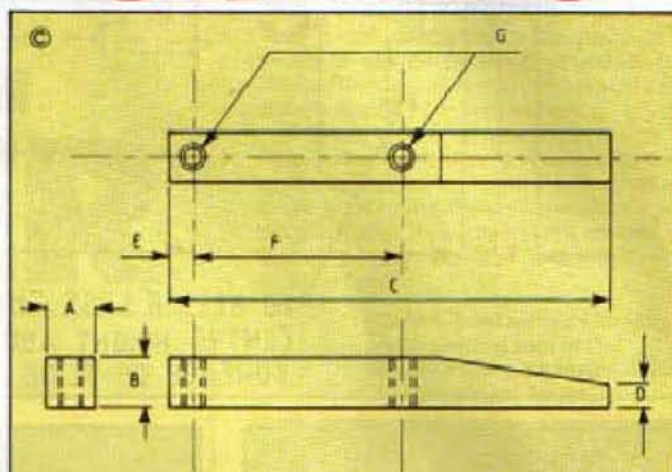
The bottle, when empty, can be used as an applicator for cutting fluids/oil, etc., the end of the spout needing to be cut off to increase the size of opening to allow for the more viscous liquid to flow.





A fine selection of clamps in a wide range of sizes.

# TOOLMAKERS CLAMPS



| A    | B    | C     | D    | E    | F      | G    | H     | J     | K |
|------|------|-------|------|------|--------|------|-------|-------|---|
| 1/4  | 1/4  | 2     | 1/8  | 1/8  | 13/16  | 1/8  | 7/64  | 9/64  |   |
| 5/16 | 5/16 | 2 1/8 | 5/32 | 5/32 | 1 1/8  | 5/32 | 9/64  | 11/64 |   |
| 3/8  | 3/8  | 3 1/4 | 3/16 | 3/16 | 1 7/16 | 3/16 | 11/64 | 13/64 |   |
| 1/2  | 1/2  | 4 1/2 | 1/4  | 1/4  | 2 1/8  | 1/4  | 15/64 | 17/64 |   |
| 5/8  | 5/8  | 5 1/2 | 5/16 | 5/16 | 2 7/16 | 5/16 | 19/64 | 21/64 |   |

NOTE: ALL DIMENSIONS ARE IN INCHES

THREADS REF 'G' ARE M.E. SERIES 32 OR 40 T.P.I.

DIMENSIONS ARE FOR BOTH HALVES

## TOOLMAKERS CLAMPS — BOTTOM HALF

**A** quantity of toolmaker's clamps available in a number of sizes, say at least two of each from quite small at about two inches long, up to say six inches long, can be very beneficial in the home workshop.

### Sizes available commercially

In view of the cost, most people will try and manage with less than this, but another factor governing the quantity found in the home workshop will be the fact that suppliers to the model engineer do not stock a wide range of sizes, they mostly supply only three, being from two inch jaw length up to a maximum of four inches jaw length; this omits the larger sizes which are particularly useful during milling operations. As mentioned below, such a limited range in the workshop can be false economy.

### Variety of uses

Toolmaker's clamps can have a variety of uses for holding parts together when soldering or brazing and are also useful for holding two parts together when requiring to drill through one into the other to ensure that holes line up.

Perhaps one of the most beneficial uses they perform is for clamping parts onto an angle plate mounted on the milling machine. This can frequently be better than trying to use the machine vice, and fixing parts onto an angle plate using clamps with packing pieces, as would be used on the machine table. The operation can be quite

**These toolmakers clamps will not present much of a manufacturing challenge but are worth making just for the benefit of having a wide range of sizes available for use.**

**Making the taper on the jaw using the lathe will enable this to be a project which can be completed purely on the lathe**

difficult, not least due to the limited space available.

For this purpose it is essential that a sufficiently robust clamp is employed and this is best ensured by having a wide range of sizes available.

### Drawings/proposed sizes

The drawing with this article shows each detail part just once in general terms but with the dimensions given in tabular form for each individual size. From this it can be seen that sizes are proposed as being made from 1/4 in, 5/16 in, 3/8 in and 1/2 in square bright mild steel. This will give a good range of sizes and strengths.

### The screw mechanism

To give a nice clamping action the screw threads have a fine pitch, being from the Model Engineer's 32 and 40 threads per inch range of thread sizes. This does have the disadvantage that they are rather slow to open and close.

If the ME range of threads is not available, then some other can be substituted, the finer the better. One thing to take note of, though, is that the centre screw passes through the point of greatest stress to the jaw and therefore should not be larger in diameter than that quoted, or else the jaw may be found to distort badly and, as a result, not grip reliably. This could even be dangerous if used to hold work being machined on the milling machine.

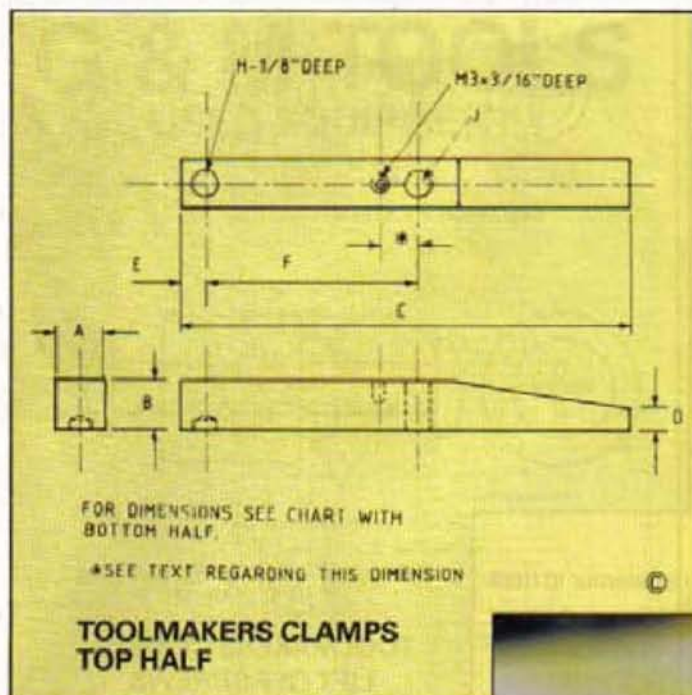
If you wish to limit the amount of work involved in making these clamps, then the small part used to make the one arm open with the screw can be omitted, as was done with some sizes shown in the photographs.

The method of captivating the arm to the screw proposed is different to that traditionally used, and for many will be easier to make than the small bent forked component more normally employed. If so desired, the screws used could be made from standard machine screws rather than made from mild steel bar.

It is worth taking note of the fact that, in some cases, it is easier to use these clamps without this facility as it permits the clamp to be held with both jaws in contact with the work with one hand, the other hand being used to rotate the centre screw till it just touches the jaw, then to tighten the clamp using the outer screw. By this means it is easier to ensure that it finishes with both jaws fully in contact with the work along their length.

With this in mind, it may be worth





considering delaying including this aspect of the design until experience with their use has been gained.

### Manufacture

Manufacture is very simple and can, if so desired, largely be done on the lathe. First, with the various sizes of material in the four-jaw chuck, part off to length followed by facing the ends.

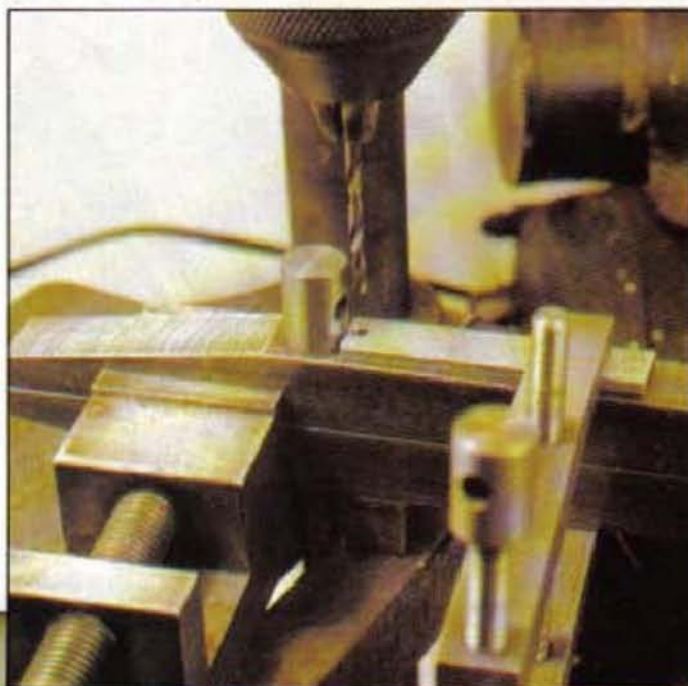
This can then be followed by mounting the two pieces side by side in the four-jaw chuck and, with the top slide set to a suitable angle, turn the tapers. Alternatively, this can be done in a more normal manner on the milling machine.

Mark out for the holes required and drill and tap to suit. Do endeavour to ensure that the tapped holes are at right angles to the bar in both axes since, if not, they will not feel right in use. If the lift off screw is to be included, do not drill for this at this stage; it will be much easier to include it by the method detailed latter.

Turn the screws and make the thread. This should be a close fit but free-running. Take note that, for each pair of screws, one should only be threaded to a distance from the head equal to the jaw thickness. This ensures that a plain portion runs in the top jaw which also has a plain hole at this point. Also cross drill for the tommy bar; this is essential if machining work is to be carried



*Note the lift-off screw (above) made from a standard pan-head screw. The jaws can be shaped on the lathe (below). Making your own is not only an inexpensive means of acquiring a useful selection of clamps, you can also end up with a far greater range of sizes than those commercially available.*



*Simple drilling jig considerably eases the task of drilling for the lift-off screw; same jig will suit all sizes of clamp.*

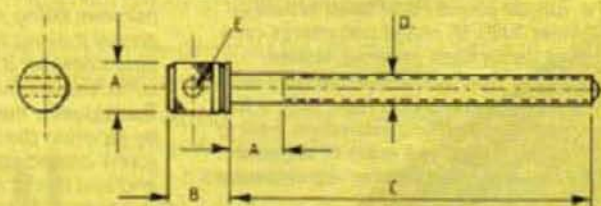
out using these clamps, as finger tight will be insufficient even with the 40TPI thread pitch.

Now make the small headed screws which ensure the clamp opens automatically with the operation of the screw. If these are to be made from standard machine screws, it will be necessary to devise some means of holding them in the lathe to produce the stepped head.

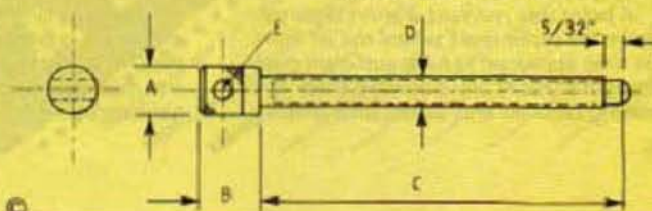
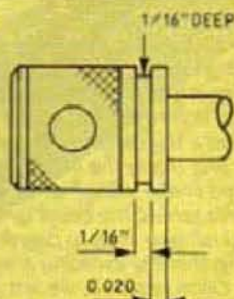
Take a short length of bright mild steel, say three eighths of an inch diameter, and as long as your M3 tap will permit you to tap completely through, drill and tap through in the lathe to produce a simple jig to hold the screws as follows.

Remove from the lathe and fit an M3 screw complete with locknut. Run this in and lock with the nut so that the screw

### TOOLMAKERS CLAMPS — SCREW PROPORTIONS



| A     | B      | C      | D     | E     |
|-------|--------|--------|-------|-------|
| 1/8"  | 3/8"   | 1 1/4" | 1/8"  | 1/8"  |
| 5/16" | 7/16"  | 2"     | 5/32" | 5/8"  |
| 5/16" | 7/16"  | 2 1/2" | 3/16" | 3/16" |
| 7/16" | 1 1/2" | 3"     | 1/4"  | 3/16" |
| 1/2"  | 5/8"   | 3 1/2" | 5/16" | 3/16" |







A set of jaws shaped on the lathe; note the curved ends.

which you intend to machine projects just sufficiently from the other end for the step in the head to be machined when run in and tightened against the first screw.

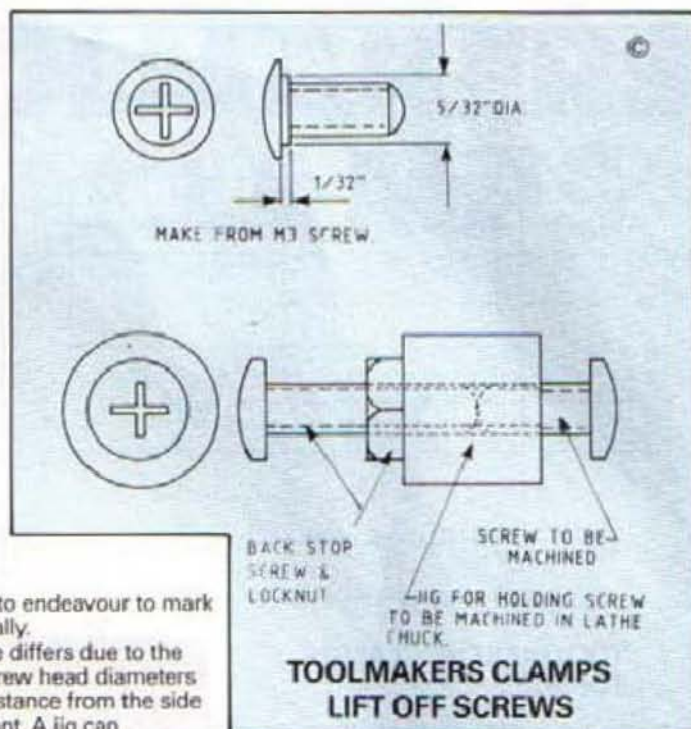
Now machine the first head, remove the screw and fit the second and machine the second and so on. It should be possible to do this without removing the jig from the chuck each time. Having completed the heads on all the screws, remove the jig and run the screw in further so that this time it will now be possible to part off each screw to the length required.

Break all sharp corners and edges from all the parts with a fine file, clean the threads and assemble using a little light oil. It now remains to drill and tap for the lift off screw. As the dimension from this to the main clamp screw is both different for each size of clamp, and also critical in view of the limited engagement between both screws, it will be easier to make a simple

drilling jig rather than to endeavour to mark each one out individually.

The centre distance differs due to the difference in clamp screw head diameters and, as a result, the distance from the side of the head is a constant. A jig can therefore be made which locates off the side of this head [see article on drilling jigs elsewhere in this issue. Ed]

Take a length of  $\frac{1}{2}$  in x  $\frac{1}{2}$  in mild steel about three inches long and drill one hole to the diameter being used to tap for the screw, and a few thou over  $\frac{1}{8}$  in from the end. This can then be located against each head in turn and clamped in position using one of the other clamps, and the clamp jaw drilled ready for tapping for the lift off screw.



### Casehardening?

Clamps purchased ready-made would be hardened and, similarly for those who wish, these could also be casehardened. However, with the limited use they are likely to get in the model engineer's workshop, in the unhardened state they will still continue to give good service over a long period, and fully repay the time and effort involved in their manufacture.

## SCRIBE A LINE

Continued from page 31

### MATTERS ARISING

Brian Taylor of Milnthorpe, Cumbria (see the Torque about Flea Power article in our Winter 1990/91 issue) comments on a couple of items from previous issues.

The letter from Mr S. R. Price may be answered by some boffin type, with a fully documented scientific explanation. Failing that, it may be near the mark to suggest that he repeats a 'circulation' experiment I recall from my school days.

We filled a school-lab sink to the overflow and added a pinch or two of the confetti from an office ring-file punch. A longish length of rubber tube was attached to the tap. With the open end of the tube suspended a fair distance above the water, the tube end made the inevitable 'demented snake' dance when water flowed. We tamed the brute by tethering it with slackish guy-lines to prevent excessive side-sway, thereby avoiding a second soaking. Once tethered, we left water flowing as the tube was lowered.

A point was reached, a short distance above the water level, where the jet from the tube appeared to have sufficient body strength to resist any sideways shear force; snaking reduced and, as the tube entered

the water, snaking ceased. The confetti by this time was circulating with the currents; down the axis of the jet, drawn in by the fast flowing water. It was virtually analogous to illustration showing lines of force entering a bar-magnet's pole, the effect being to close-in round the tube and 'damp' its movement - damp being the operative word in every sense.

Another article, 'Variable Lead Threading Attachment' in the Autumn '90 issue, kindled memories of a fitment added to a milling machine in the '30s. Rubber extrusion makes use of a glorified version of a household mincing machine. Its purpose being not to mince rubber but to propel it along a barrel and at the same time compact it to increase the pressure sufficiently to force it through dies. Traditionally, the compaction was achieved by tapering the bore so that the tapered screw picked up a large volume at its big end and thrust it into a smaller diameter at the output. That limited the size of die area.

Parallel bores were introduced, the screw being modified so that its OD remained constant but the core diameter increased towards the O/P end. It led to cavitation faults in larger dies.

In the '30s the Americans introduced a new and successful technique. A complex parallel screw with large OD, small core diameter and continuously closing pitch. A typical screw, milled from a solid billet, six feet long and ten inches diameter, had a 'thread' which, commencing at about a third of billet length, progressively shortened in pitch over its four foot run to the O/P end. It was produced by vertical end milling, the tapered cutter being typically about four inches long, two inches

down to one inch in diameter with a rounded end. Rotation of the billet had to vary as the table moved slowly but steadily from left to right. The variation in rotation had to be positive so that repeated cuts under fine feed would follow the same track without backlash effects.

Rotation was achieved by means of large steel discs,  $\frac{1}{2}$  inch thick, attached to the horizontally mounted, rotatable billets by adaptor bushes. Disc size was appropriate to the pitch pattern required, but all were in the region of two feet diameter. The surface of each had an accurately drilled snail-spiral of  $\frac{1}{2}$  inch diameter holes which engaged with a pin-studded pinion bush, arranged to slide along its shaft. In that manner, a pinion and plate pair became a variable ratio right-angle drive. Starting at the outer radius of the spiral, the pinion/disc reduction ratio was maximum, hence for one unit of traverse movement, the billet made minimum rotation. That produced a large pitch thread. (In the extreme case, no rotation at all would have produced an infinitely long pitch - a straight, longitudinal cut).

At the small end of the spiral the pinion/disc reduction ratio was arranged to produce the smallest pitch.

In other words, maximum rotation for the same unit of traverse movement. (Again citing the extreme case, no traverse at all would have produced an infinitely small pitch - a groove).

Although screw designs changed as extruders increased in capacity, the technique progressed in step. By the time I left the company in the mid '50s, extruder screws were 20 inches in diameter and lengthened accordingly.

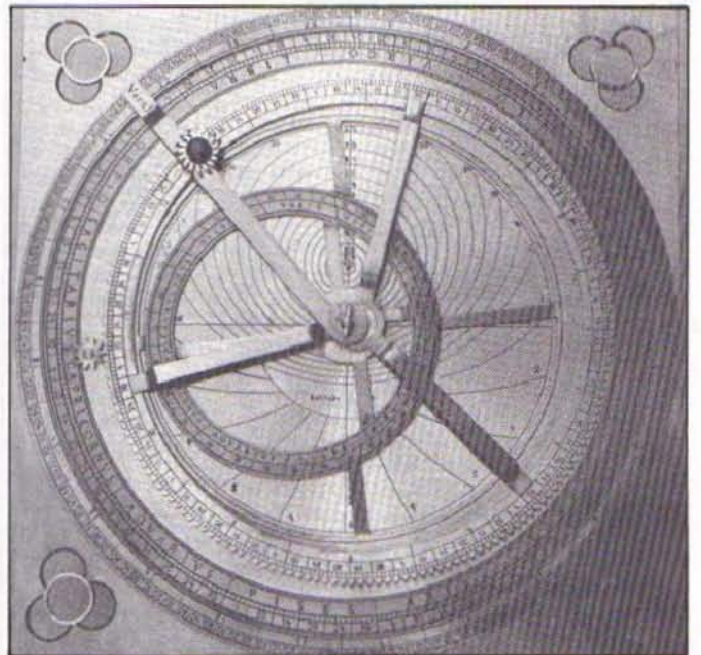
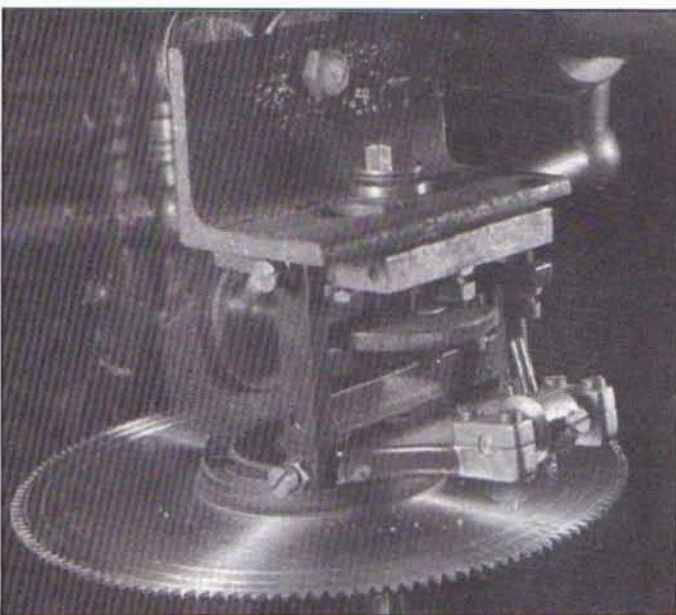
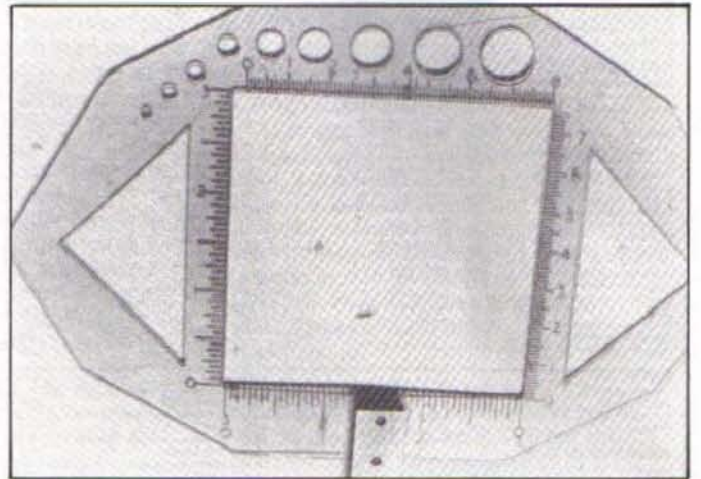
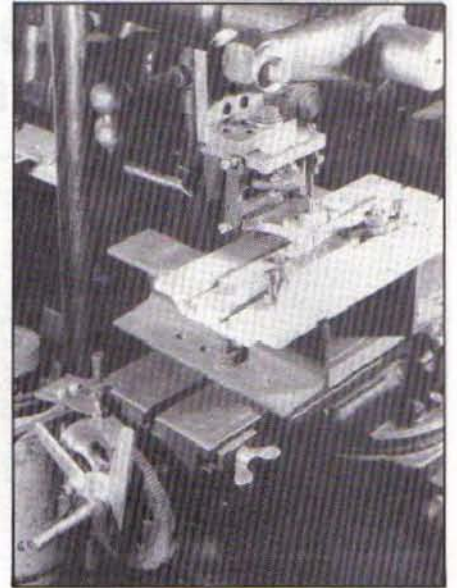
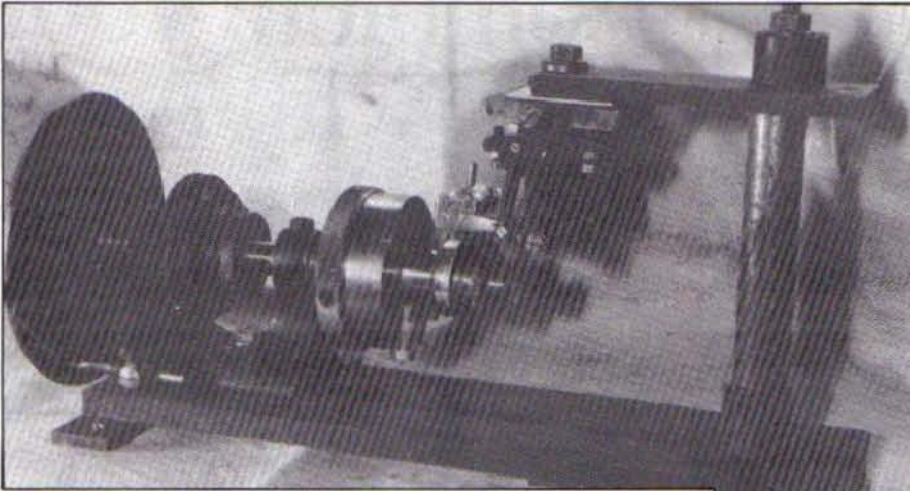


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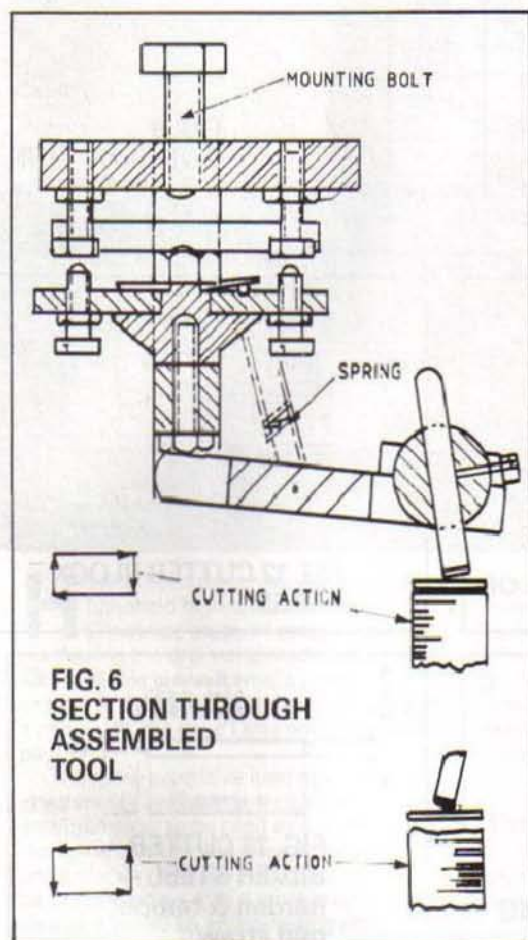
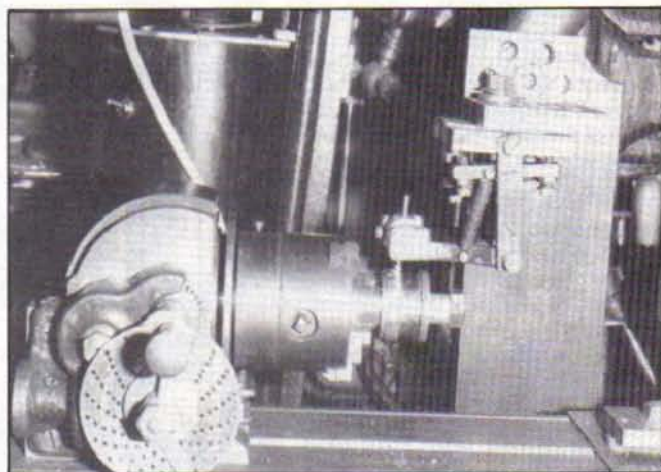


# A DIVISION LINE



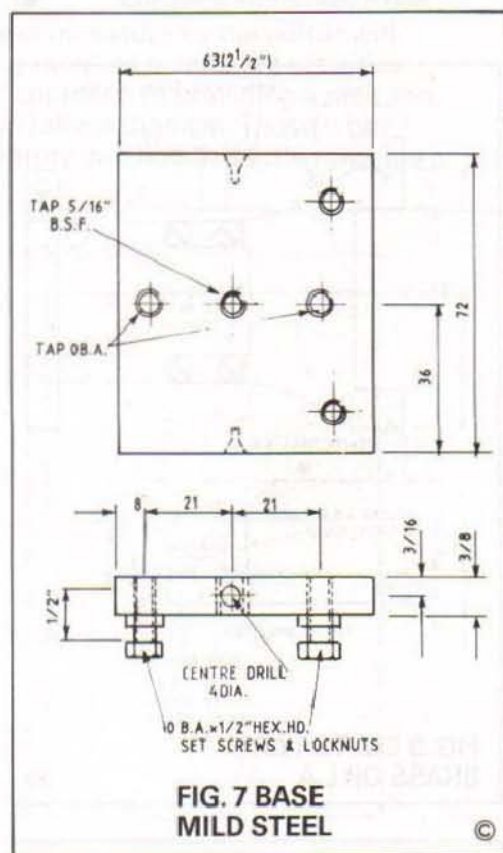
In this article from Don Unwin we have something a little different to the more normal machine tool accessory. Even if you do not intend to make this device, do read through the text as it is loaded with useful ideas. In any case, it is not immediately obvious how the device works and determining this is an interesting exercise in itself!

**M**any moons ago, when I was making a small pantograph draughting machine, I wanted to divide the scales on the drawing template and rules, as can be seen in **Figure 1**. To do this I decided to make a line cutting head similar to that used in the scientific instrument making trade for scale dividing. It is one of those tools not used very often but when dividing lines



are needed it is a valuable aid to their production. Among the jobs I have used it on were the various controls on the cine-camera I built, lathe index collars, the indexing dial on the boring and facing head but it really came into its own when making my replica Dondi medieval clock in which over 6,000 [*Where does he get the patience? Ed.*] lines were required, as can be seen in **Figure 2**.

It is quite a simple device which can be rigged up in many ways depending on the type of job being undertaken. **Figure 3** and **Figure 14** show it mounted on my milling machine dividing the radial lines on a disc mounted on the dividing head and **Figure 4** dividing a linear scale. Note the method of indexing by means of a gearwheel on the traverse screw with an adjustable quadrant to fix the number of teeth without counting each time the movement was made to the next line. For dividing index collars I now normally use the dividing head on the miller as **Figure 15** but **Figure 5** shows an earlier rig-up of mine using a division plate on an old lathe head stock. From this it can be seen that, apart from some means of dividing, no machine is necessary.



*Opposite page, top left: Figure 5. The rig-up for cutting an index collar. Top right: Figure 4. The tool in operation cutting a linear scale. Opposite page, centre left: Figure 3. Cutting radial lines on a disc. Centre right: Figure 1. The drawing template. Opposite page, bottom left: Figure 14. The line dividing tool shown clearly, this time unobscured by the author's hand! Bottom right: Figure 2. The dial of the author's replica medieval Dondi clock showing the division lines. This page, top right: Figure 15. Cutting lines on an index collar on the milling machine using the dividing head.*

The lines are cut by reciprocating the cutter back and forth by hand, pressing it down on the cutting stroke as in **Figure 6**, the different line lengths being selected by positioning the stops on the large milled edged disc detailed in **Figure 10**. A maximum of four line lengths are available, a spring click locating the disc in the correct position.

Now to the construction, shown assembled in section in the drawing **Figure 6**. The drawings give adequate details, but nothing is very critical and dimensions can be varied. Where Imperial materials were

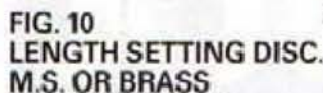
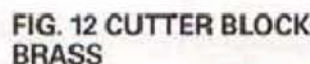
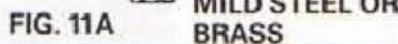
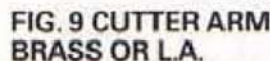
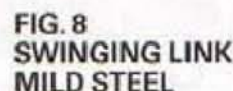
used I have given the dimensions in inches, otherwise they are in millimetres. Probably the two most important points to watch are that the cutter block **Figure 12** is clamped very tightly by the two clamp bars on the cutter arm **Figure 9** and the pivot screws are greased and adjusted closely so that there is no lateral movement at the cutter but the arms move freely.

It is a good plan whilst set up to make a number of cutters **Figure 13** of each width, preferably by means of a milling cutter either on the lathe or milling machine. It is difficult to make such short parallel cutting

# THE CUTTING TOOL



The great advantage of a line produced by this tool over a vee line cut in one pass is that the line width is independent of depth. Also the parallel groove holds fillers much better than a vee. About three or four passes are sufficient on brasses or light alloy, rather more on steel. Once the rhythm has been established, lines and scales can be cut extremely rapidly, giving the work a very uniform appearance.



Hole for stop rod should preferably be smaller at  $\frac{1}{4}$  inch diameter.



# A MINI DRILLING MACHINE

This drilling machine in miniature by the editor will provide an interesting range of machining activities, and contains a novel approach to providing a rack and pinion for the rise and fall mechanism. Those who make models in miniature will find this little machine a real asset

*The complete drill; our example utilised the popular Como Microturbo 1 but, with minor redesign, the unit could be adapted to suit many of the available mini-drill units.*

Having been presented with a small handheld high-speed drill as a Christmas present I considered purchasing the drill stand made to suit. This was available in two forms, a plastic version at a price I was prepared to pay and a metal unit at a price I was not prepared to pay!

The more expensive item has some attachments available and could be arranged so as to be used as a router; this made me consider the cheaper item as unsatisfactory and the only solution would be to make one — this did not seem a bad idea as it would be an interesting little project.

## The drill

First I must make an observation regarding the drill itself before any reader rushes out to purchase one. As a handheld unit it is perfectly adequate, but having the drill chuck directly mounted to the motor spindle and with the motor resiliently mounted within the main housing, the drill tends to move to enable it to find the softer area between the harder grain lines when drilling wood and being used in the drill stand.

This problem does not occur when being used to drill holes in metal which has been centre punched, but a similar situation will also occur when the tool is being used as a router.

In retrospect, I should have requested the slightly more expensive drill which has the drill spindle running in rigidly mounted bearings.

The drill being used is a Como Microturbo 1 and is an excellent drill for the money. The similar unit, but with added

bearings, is the Microturbo 2 and for this some redesign of the drill mounting would be required, as it would for any of the many other makes of similar drills.

Despite this reservation, the unit has proved extremely helpful in making the many small wood and metal parts for a  $\frac{1}{16}$  scale model horsedrawn cart.

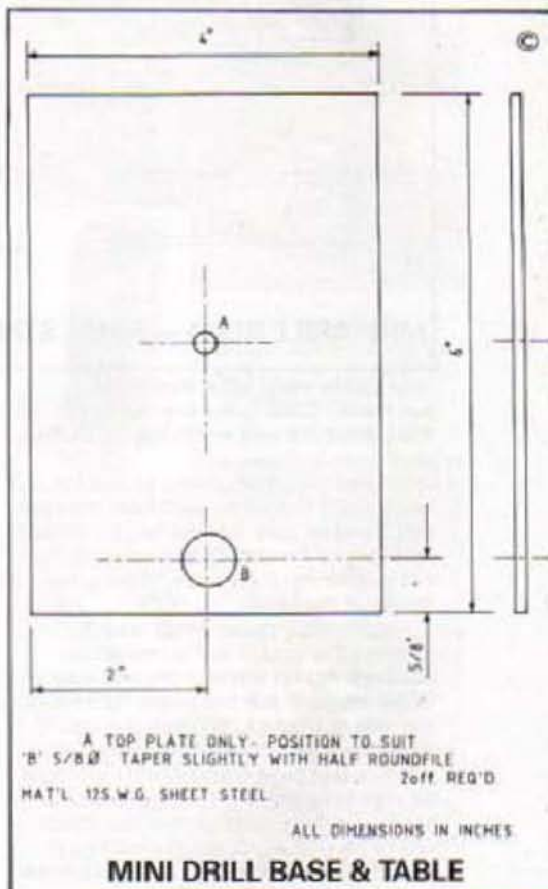
## The design

The unit uses a rack and pinion to control the vertical movement of the drill, though a simple lever arrangement could easily be substituted if a suitable gear is not available or considered worth making. In view of the non-exacting requirements for this arrangement the rack should present no problem if dealt with as detailed later in this article.

Most of the construction is very straightforward, though close examination of the photograph of the head may cause some alarm due to the apparent level of complication of the moving part. This is far from the case as most of the perceived complication is purely due to metal removal for weight reduction, and is therefore dimensionally quite unimportant.

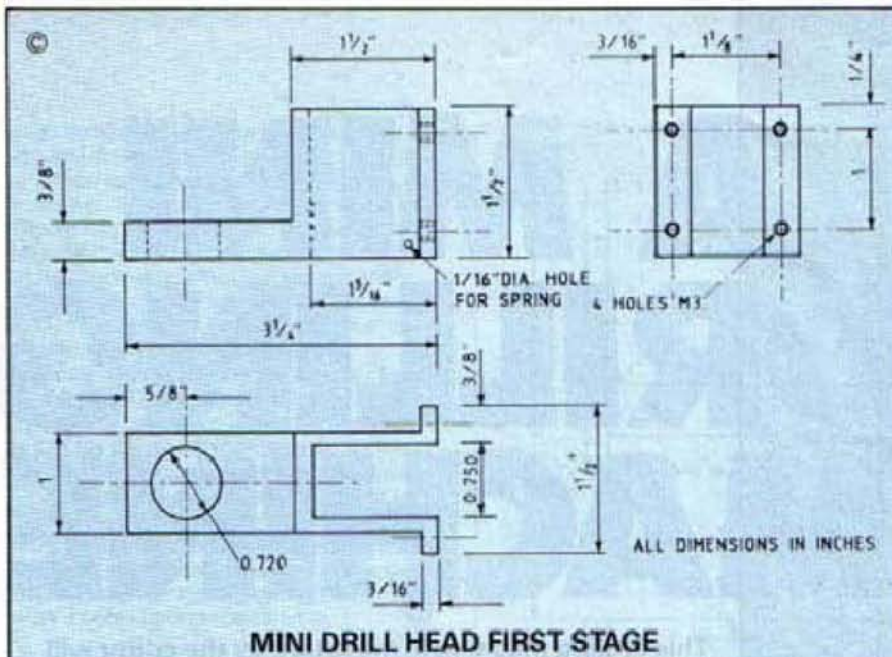
Return of the head to the upper position is achieved by a simple extension spring housed inside the head, but the more ambitious amongst you may wish to amend the arrangement to include a leaf spring of the type used in clocks, for a more professional design.

If not available, a spring could be purchased from A. J. Thomas (Bradford) Ltd or J.H.W. Clocks, Sheffield, or H. S. Walsh and Sons Ltd, Beckenham but in the latter case a minimum order charge would



*The completed head; drawings on following page outline construction.*





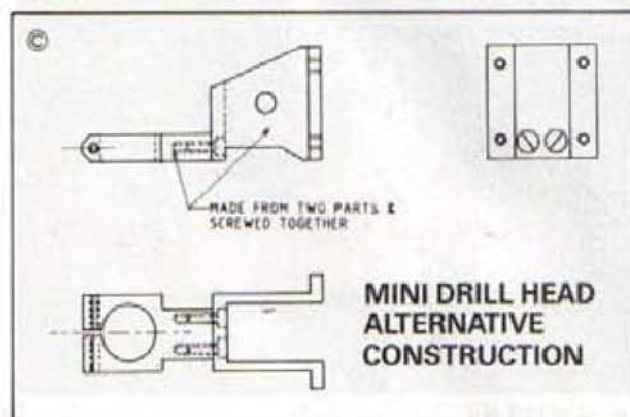
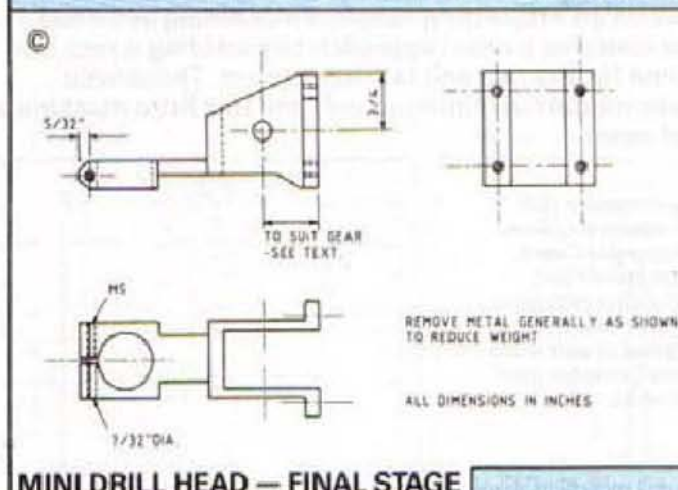
The brass fixing screws require no explanation other than to say that the small wing pieces are fixed using rapid setting, two-part resin adhesive, as also are both the drill movement operating arm and the drilling unit clamp screw arm.

**Construction:** head

We now come to the more involved part, the head. This is based on using a 48DP 40 tooth gear though the dimensions can easily be modified to suit any other suitable size gear which you may have available.

Should you wish to obtain a gear, S. H. Muffet Ltd of Tunbridge Wells (0892 542111) will supply individual gears on a cash with order basis.

A novel approach has been taken with regard to the rack which evolved as follows. Realizing that the precise tooth shape was of little importance in view of the limited load, speed, and amount of use it would get, using a screw thread was considered.



necessitate some other item to be purchased. Catalogues from all three companies are well worth having on the shelf.

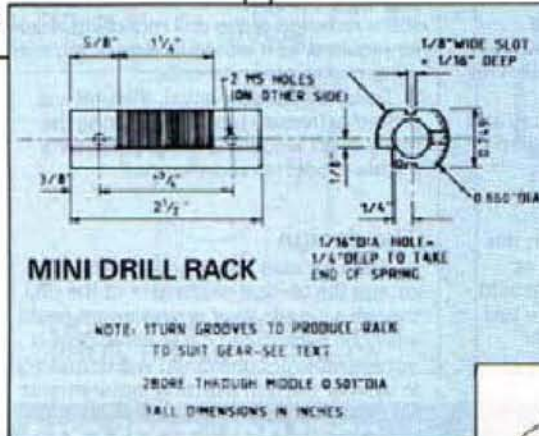
One of the photographs shows the unit being used as a router with both the head and the table inverted; the head is allowed to rest in its lowest position and depth of cut is achieved purely by adjusting the height of the table.

Again some readers may wish to improve the design in this respect by adding a thumb screw in the rear web of the head, such that the screw tightens onto the side of the rack member, this would then allow adjustment to be made using the rack and pinion, and for this setting to be maintained by tightening the thumb screw, a simple addition and one which would be well worth while including if intending to use the drill frequently in the router configuration.

The fixing screws on the rear of the head and also the table are made from brass so as to ensure no damage is done to the column, and as a result the parts will continue to run up and down freely even after much use.

### Construction: base and table

Construction of both the base and table is very straightforward and both are almost identical. The table has a hole added to allow the drill to pass through when drilling and this is best left to be done after final assembly to ensure it is drilled in the correct position. It will, of course, not be possible to drill this hole by the drill itself as



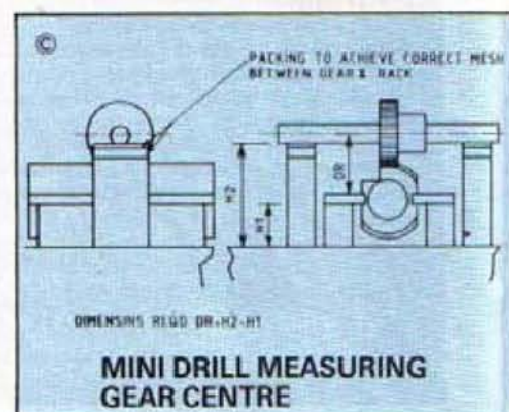
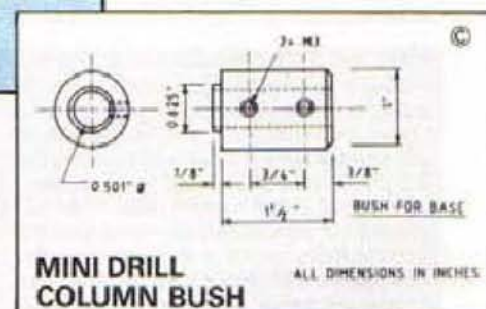
This could probably be machined to a half round section and fixed to the stationary portion of the head.

By trial it was found that the gear ran quite well along the side of a 4 in. Whit. (18TPI) tap though by observation it appeared that a slightly coarser pitch would be better. In view of this, and the fact that I did not have a suitable piece of studding, I pursued the idea further.

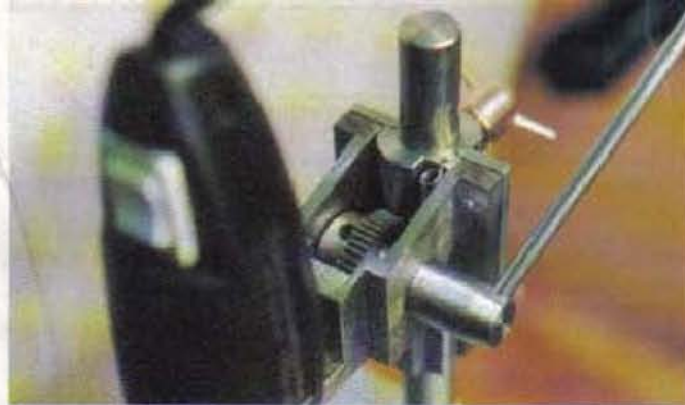
it will not be powerful enough but just use it to spot the position and then drill by other means. The only other difference is that the lower bush has two holes for fixing the column rather than the one in the table bush.

The bushes are fitted into the steel plates by riveting, the hole in the plates being slightly tapered by the use of a small half round file. With the bush standing on a heavy metal block and the plate in position, the bush is riveted using an old lathe centre (or even a good one, with much care) and a few sharp hammer blows.

The base can be fitted with four small self-adhesive feet to ensure it stands evenly; these will avoid having to finish the bush off flush — in any case, you may wish to use this drill on the kitchen table. For safety's sake, make sure sharp edges and corners are removed from these plates.



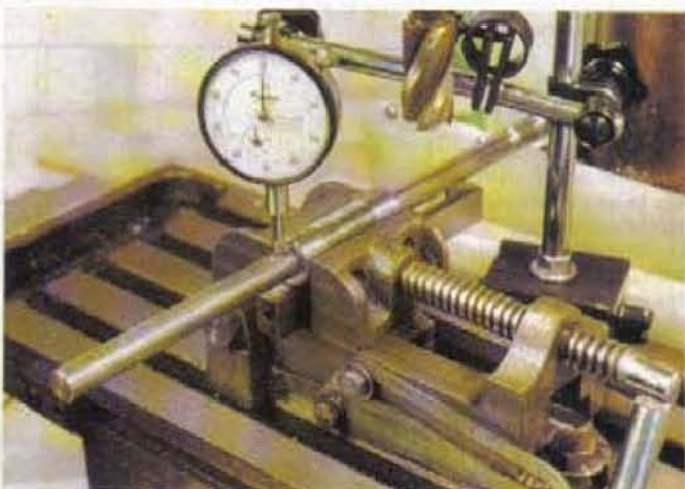




*The rack and pinion mechanism; design is based on a 48DP 40 tooth gear but dimensions can be modified easily to suit other sizes.*



*Machining the rack on the editor's Myford.*



*Make absolutely certain that the machined flat will be parallel with the bore; this shot shows testing in progress.*



*The set-up for machining the second flat; take light cuts only.*

It occurred to me that I could turn the rack directly onto the fixed portion of the head and that the teeth could be individual grooves instead of a continuous thread. This would also be preferable as the teeth would be at right angles to the direction of travel rather than at a slight angle if a thread was used.

A small shaped cutter would be made to

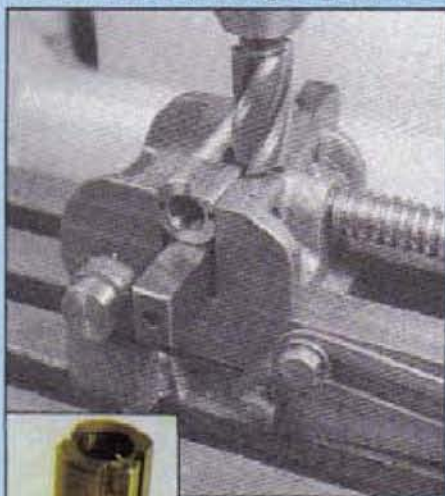
approximate to that required for a rack. Note here that gear teeth become more curved the smaller the number of teeth and visa versa. The cutter would therefore have a slightly straighter side as a rack equates to a gear of infinite diameter and number of teeth. (See elsewhere in this issue for toolholder which will avoid grinding from large square toolstock. Ed.). Alternatively, as

the gear was found to run reasonably well on a screw thread, a single point screwcutting tool could be used.

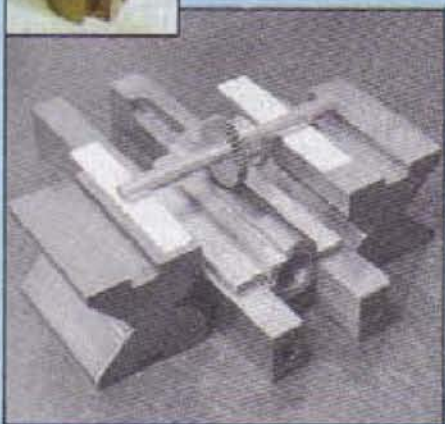
Having decided on the basic design of the head, the following procedure was adopted for constructing the fixed portion. A length of suitable bright mild steel was placed in the lathe with sufficient projecting from the chuck to enable the part to be finished and parted off without opening the chuck thus ensuring concentricity of all surfaces.

First centre drill to at least  $\frac{1}{16}$  in. diameter followed by drilling and then boring to a close fit on the  $\frac{1}{16}$  in. diameter column. This is better than drilling direct to size required, as the drill may wander off centre and, in any case, may not turn out to be a good fit.

Now support the end with a centre and commence by turning the outside diameter to size, followed by turning the grooves,



*Above, machining the groove for housing the return spring. Left, the finished rack.*



*Above, establishing dimension for the gear spindle position.*

one at a time, to form the rack at a pitch to suit the gear chosen, using either a specially ground tool or a single point thread cutting tool.

On completion, test to see if the gear runs adequately and, if not, consider whether the grooves should be widened by returning to each groove in turn, but with the cutter moved a few thou to the left, or alternatively the shape adjusted a little with a suitable needle file as the part rotates.

When you are confident about the operation of the rack, part off to length,



turn round and replace in the chuck, and face and chamfer to complete the turning operations to this part. It now remains to complete the milling operations to this component, the main problem here will be getting the essential faces running parallel with each other. First place the part in the milling machine vice and, with the column placed through the hole, test to see if this is parallel to the table surface. When this is achieved, machine flat on this side.

When machining the second flat, it is now essential to ensure this is parallel with the first flat in both the length and width axes. To achieve this the part must now be placed flat down onto the milling machine table and clamped using clamps onto the column placed through the hole. Make sure that clamping takes place evenly on both sides so as to ensure that the flat remains fully in contact with the table surface.

For those who have a high quality machine vice without jaw lift when being tightened, the second flat could be machined using a suitable parallel below the part, but even here it should be tested with the column in position as for the first flat. It is now required to machine the grooves that will allow the head to move up and down. These must run true with the flats and therefore with the bore but, even more important, also with each other. To make sure this is achieved, ensure the jaws of the vice are perfectly in line with the appropriate axis of the machine. To do this, place a flat bar in the vice and test at each end of the jaw with a dial gauge and adjust the vice to get identical readings at each end.

Having positioned the vice correctly, place the part in the vice and, again with column through the bore to ensure column is level, the first slot can now be machined.

Remove the part from the vice and turn over end to end. This ensures the two slots will still be in line even if the first was not perfectly central. Again make sure the column is level and add second slot.

Whilst the part is still in the vice, and providing it is set high enough above the vice jaws, the final flat can now be added, the purpose of which is to make space for the return spring.

It remains only to drill and tap for the rear fixing screws and also the small hole at the top to accommodate the end of the return spring.

Now comes the moving portion of the head which in its final form is a very complex shape, but in fact there are only two really important features — the space between the two rear portions which require to be a close fit on the fixed portion, and secondly the distance from the rear face to the hole which carries the gear spindle.

To simplify conveying all the requirements for this part it is drawn in two stages, first showing its essential shape and fully dimensioned, and secondly, an undimensioned view showing a suggested shape for weight reduction.

To minimize the machining required to manufacture this part it could be made from two pieces as shown in the third drawing, again undimensioned.

The order of machining the body to the stage shown in the first set of drawings is not critical but the following approach is probably the best, as the machining for the most crucial dimension is left to last, and any movement that takes place due to internal stresses being relieved will have

largely taken place when the final cut is made.

First with the block in the vice-machine first one side and then the other to form the ears at the back of the body. This can then be followed by reducing the thickness at the front where the hole for fixing the drill will eventually be.

With the part now held on the wide faces of the portion for eventually holding the drill, the slot in the rear can now be machined. First machine to full depth, but not quite to full width; this will largely relieve the internal stresses before finally machining to the finished dimension.

Endeavour to ensure that this is a close fit on the fixed portion of the head, but should this fail due to material movement as a result of this or subsequent machining, this can easily be closed using light pressure between the vice jaws. The next stage is to position the hole for the gear mounting spindle, the dimension for this being arrived at by measuring with the gear and rack meshed as follows.

Place two parallels on the surface plate or some other reasonably flat surface, and with a piece of  $\frac{1}{16}$  in. material in the slots on each side of the fixed portion, rest these on the parallels.

Now with two further parallels, higher than the first, and with a  $\frac{1}{16}$  in. diameter shaft through the gear, increase the height equally on each side with packing until just a small amount of backlash is present between the gear and rack.

Measure the height of both sets of parallels, first to check that each pair are equal in height (if not, take the average of the two values) and then to calculate the difference between the two values.

Whilst it would appear to be necessary to compensate for the thickness of the material in the slot and half the diameter of the spindle, these are both  $\frac{1}{16}$  in. and have opposing effect, the difference in height between the two sets of parallels is therefore the dimension required for that between the rear of the moving portion and the gear spindle.

Any error on final assembly between gear and rack can be overcome by either machining a little from the rear face if the mesh is loose or the inclusion of some shim material if it is found to be tight. It now remains to reduce the bulk of this part generally in line with the undimensioned drawing and care should be taken to ensure that the part is held during this operation in a manner not to distort it so that the crucial

dimension at the rear is not affected.

Finally, for this part, drill and tap the various holes required and add the slot at the front to give flexibility, this to allow the drill to be clamped.

Providing the  $\frac{1}{16}$  in. slot has not finished over size, the sliding strip can be made from  $\frac{1}{16}$  in. material, otherwise thicker steel would be required to be used and machined to suit the finished size of the slot. Apart from this, these parts are very straightforward and require no explanation.

The gear will require to be drilled to take a grub screw for fixing to the gear spindle, and the small collar made, the purpose of which is to prevent sideways movement of the gear. The collar should therefore be made of a length to achieve this. It remains only now to make the gear spindle fitted with the operating arm, and the drill clamp screw also fitted with small lever. These need no explanation other than to repeat that the arms are fitted into the main portion using two-part epoxy resin adhesive.

## Use as a router

If it is also intended to use this machine as a router, it will be necessary to make a suitable fence. The design as drawn intends this to be fitted using small G clamps or similar; alternatively, small clamps could be included in the fence if this were made longer to suit.



*Above, the mini drill set up for use as a router. Below, a view of some of the smaller parts of the tool.*









The largest of the collets in use on the editor's Myford

In this article we offer a range of collets originally made for the Myford Super 7, but which will prove a valuable addition to anyone owning a series 7 lathe. Owners of similar size lathes will have no difficulty in adapting the design to their machine — the design in principle is equally appropriate to larger and smaller machines

# LATHE COLLET ASSEMBLY

**W**hilst collets cannot be considered an essential accessory for the lathe they do have very considerable benefits, not least one of safety. As they are essentially for the smaller sizes of material it follows that the lathe will be running at high speed, maybe in excess of two thousand revs per minute. A chuck running at that speed is very intimidating!

The other real advantage of the collet is one of accuracy. If made with this in mind, they will run much more accurately than a three-jaw chuck and, with care, continue to do so, even if, as in this case, they are not hardened.

## Types of collet

Collets for the lathe headstock operate in one of two ways: in one way they are pulled into the tapered body by means of a tube attached to the rear of the collet and passing through the spindle bore, being tightened by means of a handwheel threaded onto it at the change wheel end.

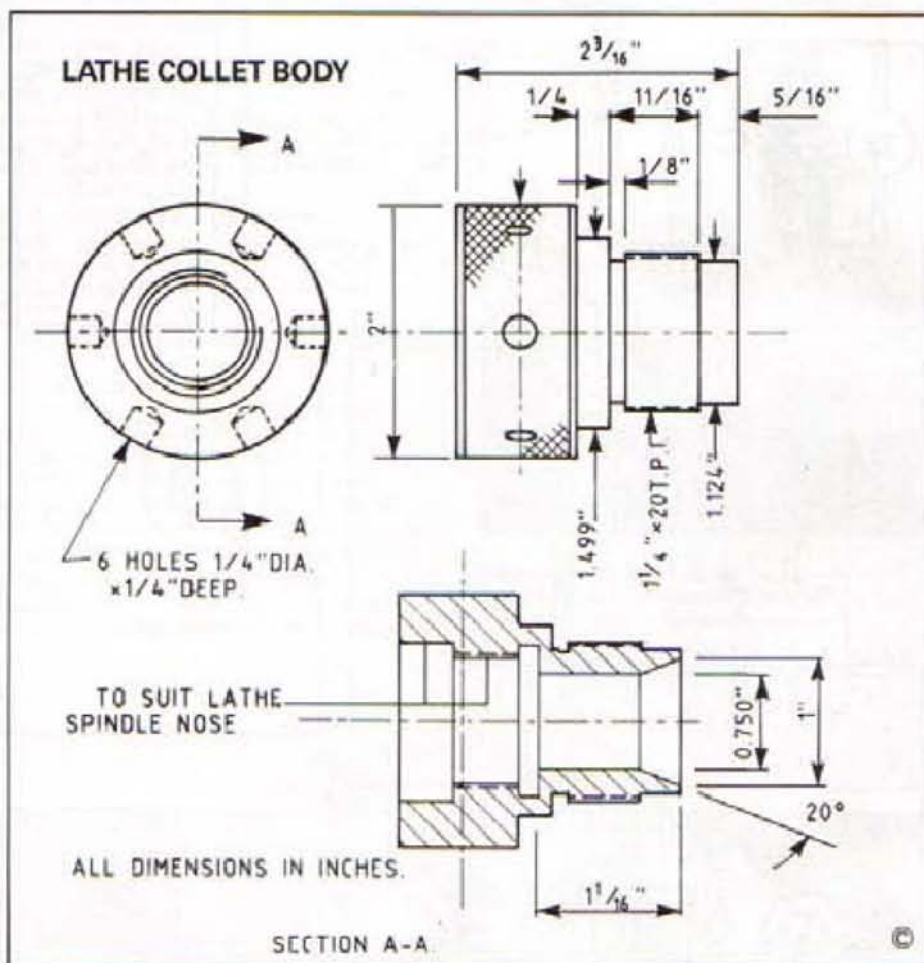
In the other method a ring threaded onto the body pushes the collet into its taper.

The first method has the advantage that there are no rotating faces rubbing together at the collet whilst it is being tightened, thereby reducing wear on its critical surfaces. The second method has the advantage that the maximum size material it can take is limited only by the inside diameter of the lathe spindle bore, which in the first method would be limited by the draw tube inside diameter.

More expensive types which can be purchased are capable of being opened and closed whilst the machine is running, this being of particular benefit for quantity production runs. It is here that the safety aspect of the collet system really becomes an essential feature.

## Chosen type

The collets being described in this article are of the type with the closing ring as it is considered that the benefit of



greater capacity is more important than that of wear and tear, particularly in view of the limited use they are likely to get in the home workshop.

Similarly, in view of the minimal use, they are made from normal bright mild steel, which with care to ensure that the mating surfaces are clean when assembled,

will give satisfactory results over a long period.

## Construction

Construction is relatively straightforward with the main consideration being one of precision and concentricity. The first item to be made is the body, but first it will be



necessary to turn a gauge equal in diameter to the lathe spindle nose, this to be used when turning the internal bore of the body. Additionally, turn the first  $\frac{1}{16}$  in. of the gauge to five thou below spindle diameter, this being to give early warning that the bore approaches required size.

The final accuracy of the collets will depend very much on a close fit between body and spindle and so when the instruction is to make gauge equal to spindle diameter it does mean plus and minus 0.000in.

## The body

Now place the material for the body in the chuck and turn the outside just sufficient to ensure it is running true and create the knurled surface. You may be tempted to consider leaving this until the part has been fitted to the lathe spindle nose, but this should not be done as knurling requires a high turning torque and it may become difficult to remove, due to it becoming over tightened on the thread, particularly in view of its small diameter and also the absence of tommy bar holes at this stage.

First drill through at about  $\frac{1}{16}$  in. diameter; this will allow for eventual boring to collet body size. Follow this by increasing the diameter for creation of the thread to suit the lathe spindle nose. No details regarding the thread are included here as it will vary from one make of lathe to another as this design is likely to suit any medium size lathe (that is 'medium' as far as the model engineer's workshop is concerned).

Note that the thread is being produced before the parallel portion. This is considered preferable as it leaves the final crucial parallel portion till last and permits this to be tested on the spindle which would not be possible if the thread had still to be made.

The thread should be cut with a single point internal thread cutting tool, the recess at the bottom of the bore allows the leadscrew to be disengaged as the cutter reaches the recess without stopping the lathe.

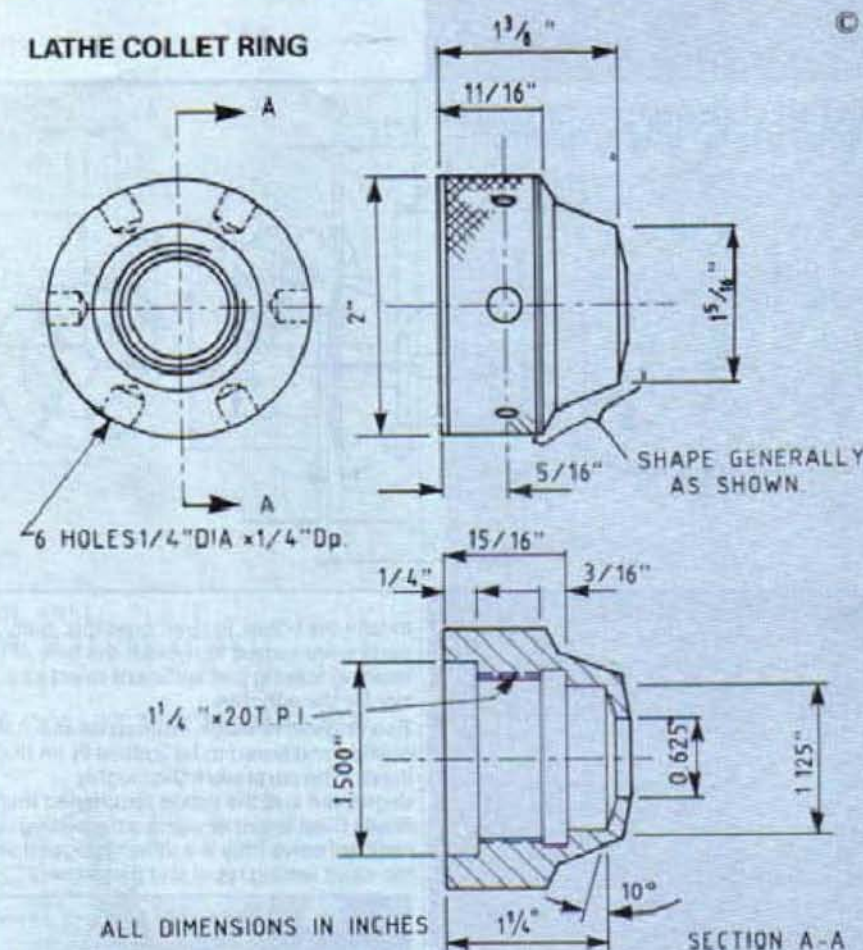
When it is considered that the thread approaches the correct size, remove the part complete with chuck and test. Continue until the part screws on freely. It is preferable that it is a little on the loose side as this will ensure that the final fit is purely governed by the parallel portion.

When the thread fits adequately, proceed to create the parallel bore. It cannot be stressed too much the importance of ensuring a very close fit. Start by boring to the required depth until the first portion of the gauge (5 thou under size) enters the bore.

From here proceed with extreme care, this time boring to about a depth of  $\frac{1}{16}$  in first, then testing each time with the gauge before proceeding to the full depth.

When considered that the bore is as required, again remove the part whilst still in the chuck and test on the lathe spindle. If the part is considered to be a little tight, do not return and attempt to open up using the boring tool, because, should the chuck not be a very good fit on the spindle, it may return a little off centre and a non-circular hole result. Should the hole require to be opened up by a tenth of a thou or two, stick a piece of emery onto a piece of, say,  $\frac{1}{16}$  in. diameter dowel, and use this to open up

## LATHE COLLET RING



the bore whilst the machine is running.

When confident that the part fits adequately, remove from the chuck and fit to the lathe spindle ready to continue with the rest of the machining. Open up the bore and produce the taper but still leave a little for final machining at a later stage.

It is now time to produce the external fine thread and the two parallel portions, the purpose of which is to locate closely with the mating parts in the outer ring thus ensuring that this runs true. Proceed to turn the three parallel portions and also the square cut groove used to assist in cutting the thread.

In view of the narrow groove it will be easier to cut the bulk of the thread using a single point tool, disengaging the leadscrew as the cutter enters the groove, and without the need to stop the machine, then finishing with a handheld chaser with the lathe running at a slow speed, quickly removing the chaser as it first enters the run out groove.

If a suitable chaser is not available, the thread can be left as cut by the single point tool but it may not run so smoothly.

For the thread of twenty threads per inch, use a driver gear of twenty teeth on the lathe spindle and a gear of fifty teeth on the leadscrew, with a suitable (probably sixty to seventy tooth) idler between. This assumes an 8TPI leadscrew.

Not being a multiple of lead screw pitch (that is eight threads per inch) the lead screw clasp nut cannot be closed in any position and the thread dial indicator must be used, but being an even number the clasp nut can be closed at any of the calibrated positions. Had it been an odd number, then it would have to be closed in either of two opposite markings, and for a half pitch it must be closed only in the

same position each time. The dial would require to be marked for odd and half pitches, say with a chinagraph pencil.

Should chasers only be available in pitches other than twenty, bear in mind that a fine thread is preferable both in ease of manufacture and also final use. A range between sixteen and twenty-six could be considered suitable.

Remove the body from the lathe and thoroughly clean the spindle nose and mating part of the body, lubricate with a heavy oil and return to the lathe. This is a procedure which should always be carried out when fitting the collet system so as to maintain accuracy.

Now finally finish the bore and also the taper position, use sharp round nose tools so as to ensure a good finish; this will minimize friction between parts when being tightened in use. The angle of the taper is not that critical at this stage as the collets will require to be matched to this when the top slide is eventually set for making them.

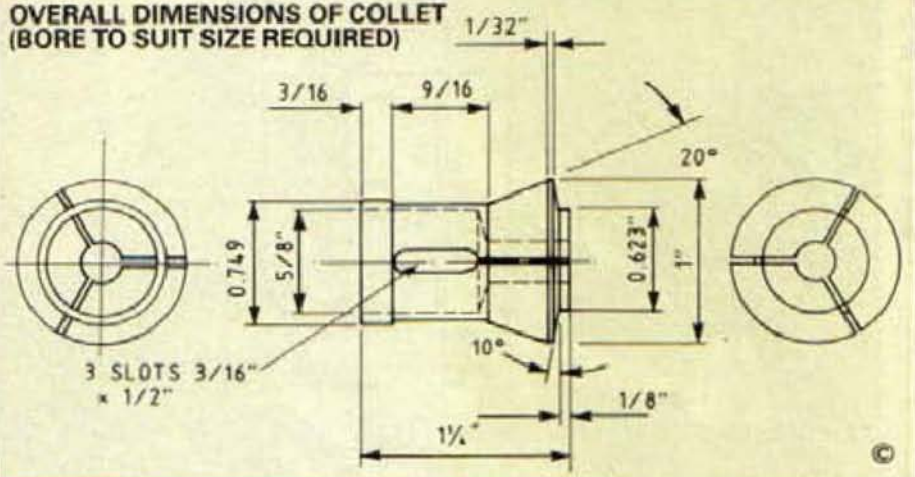
## Closing ring

It is now the turn of the outer ring. Once again place material in the chuck turn the outer surface to get it true and then produce the knurling. Drill through at about  $\frac{1}{16}$  in diameter and bore out to 0.625 in. diameter; this is to be eventually a good fit on the short parallel portion at the end of the collet. This accuracy would appear to be of little consequence but its main purpose is to prevent, as far as is practical, the entry of swarf into the inner parts of the assembly.

The next stage is to bore to the smaller of the two diameters and to the full depth required, this to be a close fit on the smaller portion of the main body.



# OVERALL DIMENSIONS OF COLLET (BORE TO SUIT SIZE REQUIRED)



If you have any doubt regarding the ability of the lathe to produce a parallel bore, a gauge able to test this bore to its full depth should be made before starting this part — the main body will not be able to test at this depth being the point where the parts will eventually be required to mate.

Unless the top slide has been very carefully set to turn parallel, precision turning should always be carried out using the saddle.

It is now required to turn to a suitable diameter for the threaded portion; also, to avoid having to produce unnecessary length of thread, bore out the larger diameter but not yet to its full size.

Now produce the groove for the thread tool to run into and commence to produce the thread, again using a single point tool if available. This would also benefit by being finished with a handheld internal chaser. Do not be tempted to try to achieve a close fitting thread as it is essential that it is free running, and in no way prevents the final assembly mating properly on the two plain turned portions. In any case, as the larger bore is not yet finished to size, it will not be possible to test to the full depth of the thread.

To enable the two parts to be fully assembled, finish the larger bore to its final size; again this should be a close fit on the corresponding diameter of the body.

At this stage the two parts should be a close fit but still rotate freely and any final adjustments should be made now before carrying out the final operation as follows.

Set the top slide to eighty degrees and turn the innermost face of the ring making sure a good surface finish is achieved. The part can now be removed from the chuck.

The outer part of the ring can eventually be machined when assembled onto the body and fitted with a non-slotted collet.

## An initial failure

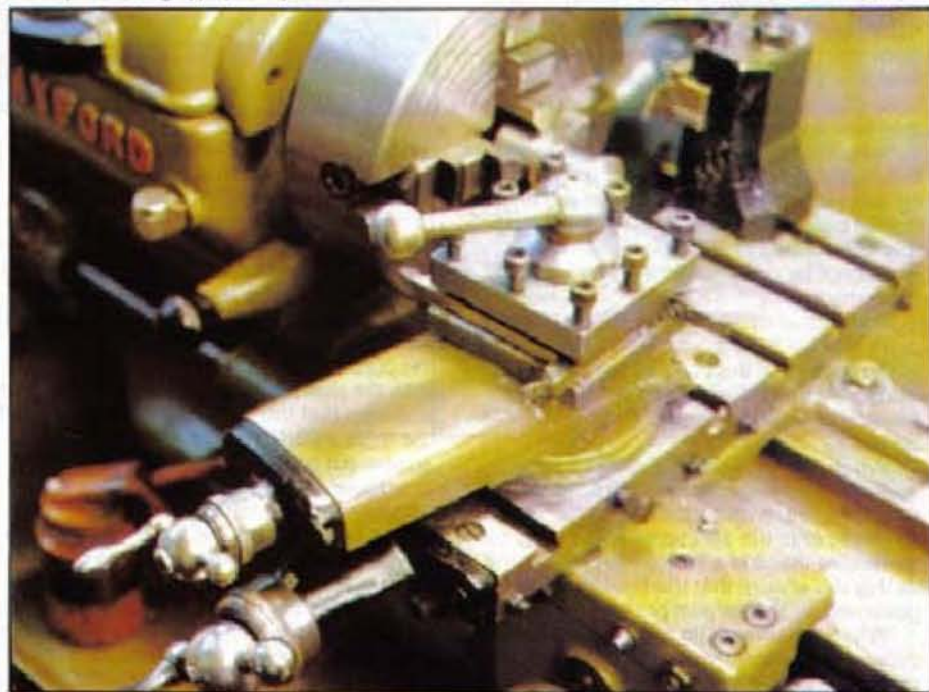
At this point it is worth admitting to a failure in the design of the original prototype! This was eventually overcome by some modifications and the use of adhesives and for this reason is included as a point of interest.

Initially both body and ring were made from 1 1/2 inch diameter steel and knurled at that size but the resulting assembly proved to be a little difficult to tighten sufficiently. Holes for tommy bars would be one solution, flats for spanners another.

Tommy bars appeared to be the best idea but the parts had insufficient thickness

to take the holes. To overcome this, both parts were turned to remove the bulk of the knurling leaving just sufficient to act as a key for the adhesive.

Two rings were made, knurled on the outside and bored to be a close fit on the inside. The parts were thoroughly degreased and the inside roughened then finally fixed together using slow setting resin adhesive (this is a little stronger than the rapid setting type) and placed on a



Here the top slide is set to 80 degrees for machining the collet front face.

radiator to give it a little heat which increases strength still further.

After drilling holes for tommy bars and remachining some surfaces, all evidence of being made from two parts was lost and the joints show no sign of failure after much use.

Now to return to the construction. Next drill the holes for the tommy bars in both the ring and body. This inclusion of six holes in each part ensures that a bar can be fitted in each, only a short distance apart, and as a result opening or closing can be achieved by squeezing the two bars together in one hand, much easier than using two hands.

When making the tommy bars these must be a close fit in the holes as this will make certain they stay in under pressure

and also prevent the holes becoming distorted with use.

## The collets

Cut a piece of one inch diameter bright steel 3 1/2 in. long to make the collets. This is long enough to make two with only one piece of waste in the middle thus economizing in the use of material.

With the material in the lathe, first rough turn the outer diameter and also the taper followed by drilling 3/4 in to the depth required. It is worth pointing out at this stage one factor which will affect the final accuracy which is not immediately obvious. Should any part of the collet be made in such a way as to make one segment more flexible than the other two, then when being closed it will bend more than the other two and therefore make the material being held run off centre.

This factor highlights areas of some importance that could be overlooked. These mainly fall into two items: first, the hole in the rear of the collet. If this runs out of true, it will make one side thinner than the other. Secondly, the slitting into three may not create equal segments.

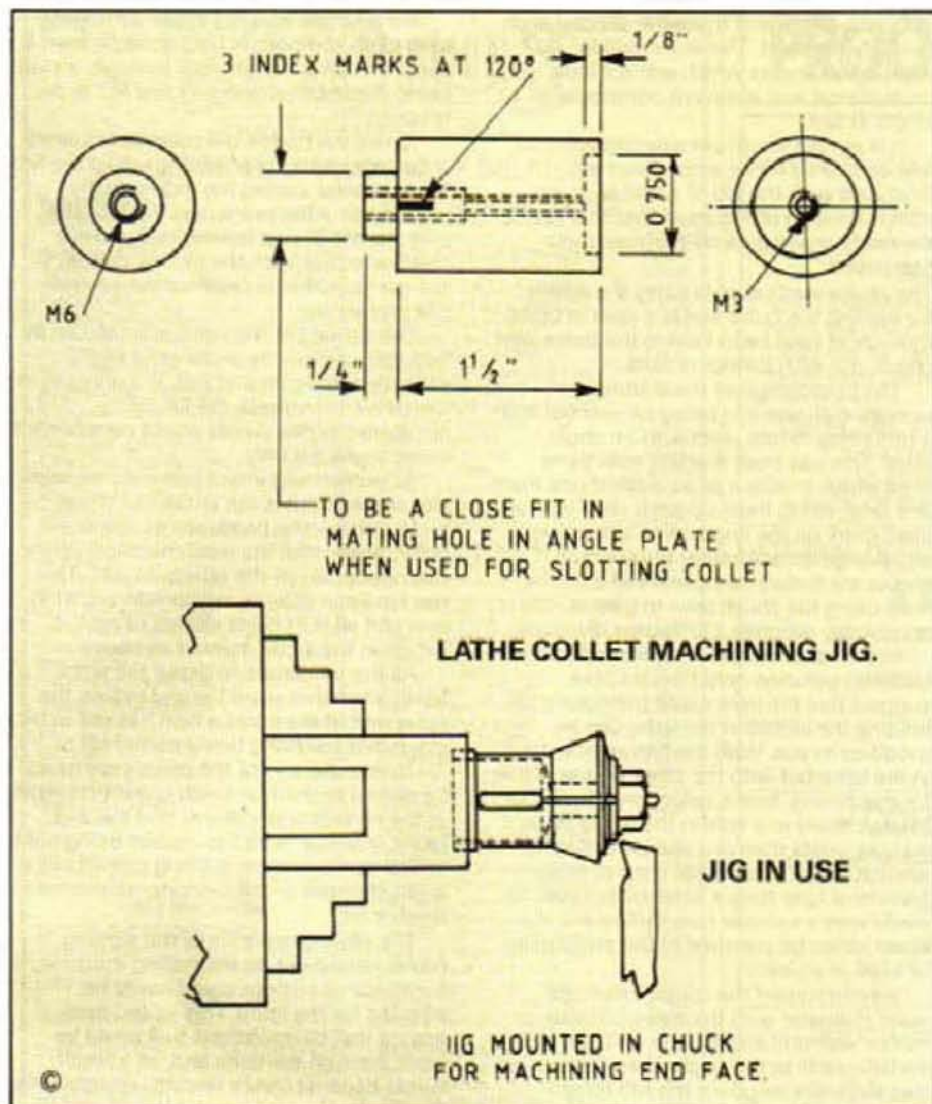
As collets are intended to be used with material that closely fits the bore before tightening, and it is therefore not required to flex by very much, the error will be minimal, but if the part being held is a few

thou undersize, then the problem may arise and is worth considering.

This situation can easily be observed by placing a collet into the body complete with ring but without material inserted, then tightening until the collet is seen to close. If two slots are seen to close more than the third, then the segment between the two slots is closing by more than the other two.

Returning now to the manufacture, it is realized that if the 3/4 in. hole as drilled does not run true, it will be necessary to bore this out to achieve concentricity, the actual diameter not being that important. Follow this by drilling a 3mm hole in the base of the existing hole so that this will pass right through after parting off. The purpose of this will be explained later. This is on the





basis that the smallest size to be made will be  $\frac{1}{8}$  inch.

Should sizes smaller than this be required, then omit this hole for these sizes only and a differing method of final manufacture will have to be adopted.

Now first turn the parallel part to be close fit in the main body followed by the taper. As the top slide has to be reset in view of the taper being required to be

turned the other way, it will be necessary to check this thoroughly against the taper in the main body. To do this, coat the collet lightly with engineer's blue and then place the body over the collet and rotate with only a little pressure. The blue should show signs of touching over the full length of the taper but with it biased towards touching most at the largest diameter. Continue to adjust the top slide till this ideal is achieved.

The reason for creating this deliberate error is that, as the collet is flexed, the angle will change due to it bending from a fixed point at the non-slotted end. The change will be such that the point of contact will tend to transfer to the smallest end of the taper which, not being the best point for its most efficient working, must be avoided.

Because of the time involved in achieving this setting it would be best to manufacture all the collets required at this stage, and even a few spares for use at a later date.

Having created the parallel portion and also the taper, follow this by using a round nose tool to produce the narrowed part, the purpose of which is to increase the flexibility. The part can now be removed and reversed in the chuck and a second collet made in the same manner.

Do ensure that all collets are made with the narrow end the same dimension, as not only does this have to be a close fit in the main body but is also used as location for further machining, as will be described later.

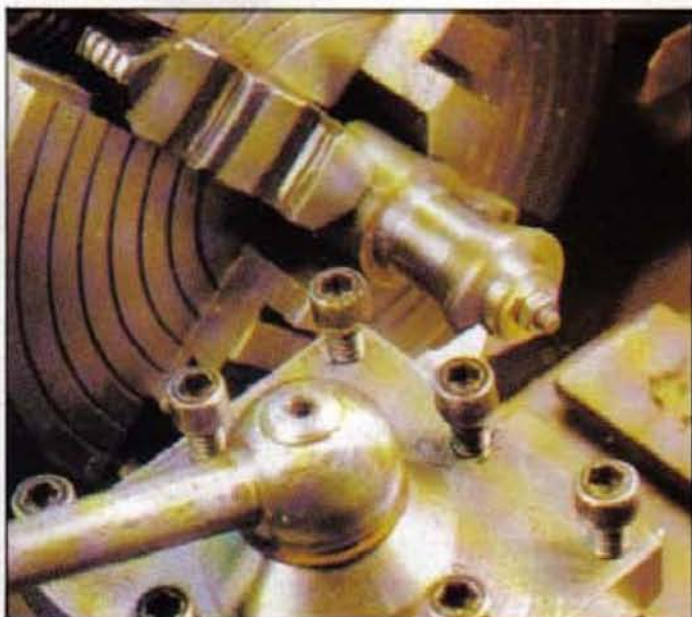
To minimize machining at a later date, use the parting tool to roughly remove metal in the area of the short in. diameter part of the collet, then move the parting tool to the left and part off fully. Turn the material round in the chuck and part off the second in a similar manner.

Continue to produce the quantity of collets required — even if it is not considered necessary to make spares for the future, it is worth making one or two additional blanks in case of spoilt parts in subsequent machining.

### Machining jig

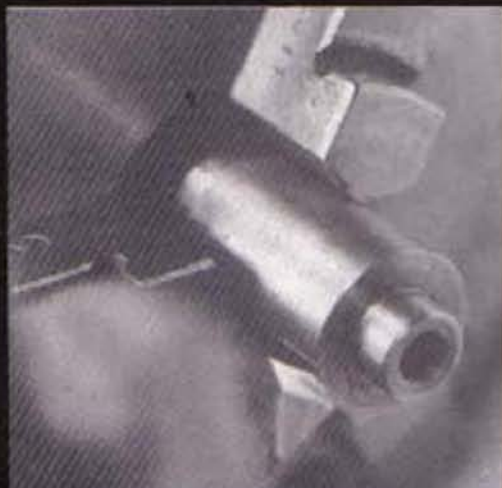
It now remains to finish the outer end of the collet. To do this, some method of consistently holding them in a concentric manner is required. To achieve this, place a piece of one inch diameter steel in the chuck and face this, then bore to a depth of  $\frac{1}{2}$  in. and a close fit on the inner end of the collet. The bore should have flat bottom.

Drill and tap M3 and, with a long M3 screw or piece of studding, fix a collet in position, set the top slide to eighty degrees and carefully turn the outer face also the 0.625 in. diameter. Again it would be



Left, using the jig to turn the collet front end — see drawings and text. Above, slotting the collet on the milling machine; note index marks on the mounting jig and angle plate.





**Marking the three index lines on the collet holding jig using the chuck jaws as reference.**

preferable to use engineer's blue to check the precise angle.

In view of the method of holding the part, machining should proceed with caution taking light cuts only. If all the collets cannot be completed at the same time, it would be necessary to turn another holding fixture, as returning the original fixture to the chuck, it would be found to be very difficult to ensure both circumference and base of bore were running true.

Prior to boring the collets and whilst the chuck is still fitted on the lathe it would be preferable to produce a series of gauges, one for each size of bore to be created as was suggested regarding the gauge for the lathe spindle nose. Turn these to the exact diameter required, but with a short length at the end of the gauge made five thou undersize, this to indicate that the bore approaches required size.

The next stage is to bore each collet to the size required and also to finish the outside of the closing ring. Remove the chuck from the lathe spindle and replace with the collet assembly body. Make sure that the mating surfaces are perfectly clean and lubricate before assembly. Similarly clean and lubricate the collet to be bored, also the outer ring, then assemble and tighten.

The closing ring can now finally be turned to shape and at the same time the outer faces of the main body can be cleaned up. If done with a sharp round nose tool, this will give a good surface finish and a good transition between the smooth and the knurled surfaces.

Now commence to produce the collets each with the bore required starting with the smallest size as any failure in creating the bore will still allow it to be used for a larger size.

Do not be tempted to drill to the final size as the drill may wander off centre or maybe drill over size. It is essential therefore to drill to a smaller size and open up with a small boring tool (See article re. toolholder. Ed)

Make sure that the bores are finished exact size as, if over size, errors in concentricity are more likely to occur as explained earlier in the article.

### Slotting the collets

Finally it remains to slot the collets. Do not be tempted to just place the collet between the jaws of a vice and make one

slot, then rotate and make the second and similarly the third. This will result in unequal segments which will not look professional and again will contribute to errors in use.

It is always worth considering whether any item to be made would best be produced with the aid of some specially constructed jig or fixture, rather than using the ready-made general-purpose tools purchased.

The above method of holding the collets for turning the outer end is a case in point; they could have been held in the three-jaw chuck, but with inferior results.

The photograph of the slotting operation shows this being carried out with a mounting fixture used with an angle plate. This has been marked with three lines which enable it to be rotated one mark at a time, lining them up each time with a fixed mark on the angle plate to achieve equal segments. Another photograph shows the fixture being marked with the lines using the chuck jaws to give reasonably accurate 120 degree divisions.

In this case the fixture was made for the slotting operation only. I would now suggest that the item made previously for holding the collets in the lathe can be modified to suit. With the fixture now held in the lathe but with the other end available for machining, turn a spigot on this end to locate closely in a hole in the angle plate. If no hole exists then one can be drilled, or alternatively if you do not wish to make an additional hole then a small plate could be made with a suitable hole drilled and this could either be clamped to the angle plate or used in a vice.

Having turned the spigot, mark the outer diameter with the three calibrating marks, also drill and tap the end, say M6, for fixing this to the angle plate. Do ensure that sufficient length of the M3 thread remains as this is still required for fixing the collet into the fixture during slotting.

If the fixture was not made sufficiently long to accommodate both threads, then it could be threaded M6 right through, a stud being made M6 at one end and M3 at the other.

To use the fixture the collet is mounted at one end with the M3 fixing whilst the M6 fixing is used to hold the fixture to the angle plate. After producing the first slot only the M6 thread is loosened and the collet, together with the fixture, rotated to the next position to produce the second slot and so on.

The slotting of the collet is produced in two stages. First the wider slots are produced using an end mill, the purpose of which are to increase the flexibility, compared to that which would be achieved using a saw cut only.

As perfect alignment between the wide slot and saw cut is not critical, all three wide slots can be produced on the one collet, and whilst the machine is set-up for this operation, on the others as well. The machine can now be set up with a slitting saw and all the collets slotted using the fixture in the same manner as above.

All that remains is to deburr the slots using a suitable small file and to face the outer end of the collet which has still to be machined following being parted off.

To face the end of the collet each must be placed in position holding a short length of the correct size material and the end faced, together with the material being held. Whilst this operation is being carried out a slight chamfer on the 1/4 in. extension would finish it off.

The photographs show the slotting being carried out on the milling machine, but these operations could easily be adapted for the lathe. This would then ensure that all operations that could be done on the lathe and, as a result, would become a very rewarding activity for those who do not have the use of a milling machine.

### QUICK TIP

The louvered panels used for hanging plastic storage bins are expensive, but a cheap and easily made alternative can be constructed from a scrap of chipboard and some large-headed nails of the type used for fixing roofing felt.

Mark a line on the board in a suitable position and drill small holes at suitable intervals (probably two for the small size and up to four or five for the larger sizes

of bin).

The small holes will ensure the nails finish at right angles to the board and are in line. Also be sure the holes are small enough to still give a firm fit to the nail. Leave the heads just proud of the board surface to permit the lip of the rear of the bin to fit over the nail head. Use a thin piece of metal as a gauge to ensure all heads are mounted with the same projection.





# CHRONOS

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| Hobbymat Milling Table      | £380.00 |
| Norwick V360 Bandsaw        | £230.00 |
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| Talstock Quick Release Kit               | £10.00      |
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| Lathe Centres       | 1MT-£2.50            |
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| Monroe Taper Sleeve | 1-2 £3.75            |
|                     | 1-3 £4.75, 2-3 £4.75 |
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| Talstock Die Holders Quind                  |        |
| Head 1/2 or 3MT                             | £39.75 |

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|                            | £28.75 4" £39.95 6" |

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| HSS British Countersink 10.4mm    | £8.75  |
| HSS British Countersink 12.4mm    | £10.50 |
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| 36pc. HSS Metric Tap + Die Set    | £22.95 |
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| Conecut Taper Drill 9.5-22.5mm    | £11.80 |
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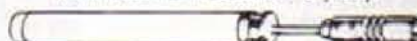
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**W**e will all, at one time or another, have attempted to tap holes into thin sheet metal with varying degrees of success. At best we have lost the first thread or two and at worst we have almost opened the hole out to screw diameter with little or no thread left. This is particularly a problem with the softer metals such as aluminium.

Success will largely depend on care, a good quality tap and the correct cutting lubricant. Ground thread taps are very expensive but well worth the money, at least for the smaller sizes.

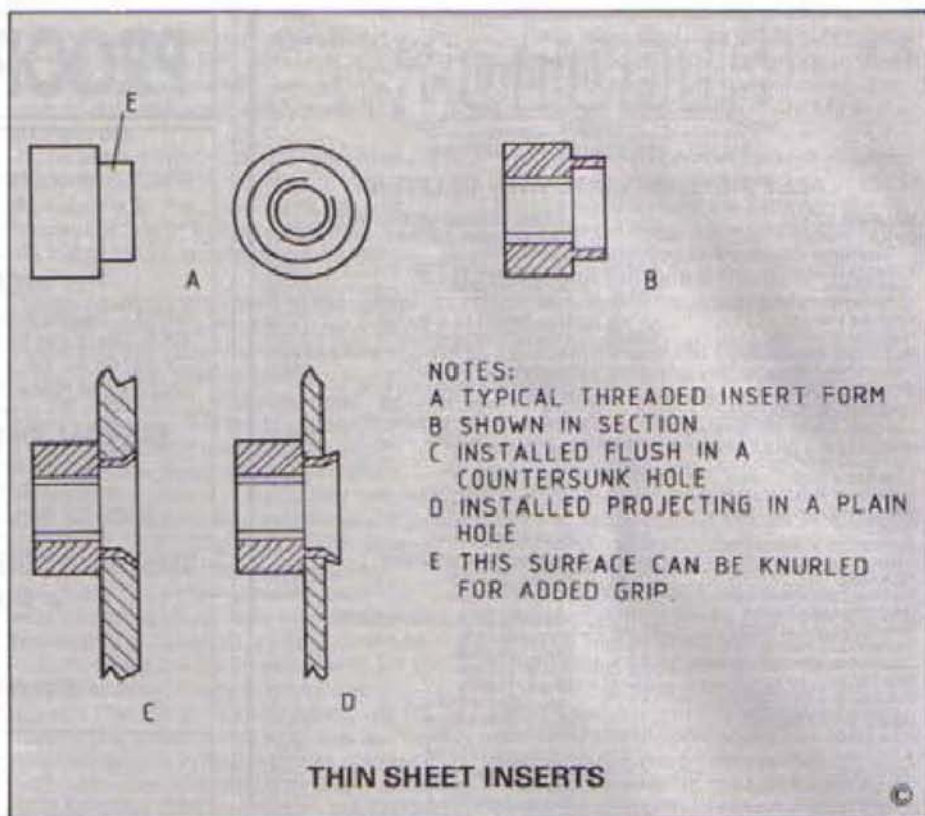
### Threaded inserts

In industry threaded inserts will frequently be used and should not be overlooked in the home workshop. They can easily be made in the lathe from bar material or even made from an available nut. The sketch shows the simplest method of making and installing these; they can be round or hexagon in shape.

Also in industry holes will be tapped using good quality taps, and in a machine which feeds the tap down at a rate corresponding to the thread pitch.

### Roll taps

Probably the best method employed though is the use of cold forming taps. These do not have flutes and remove no metal but have a tri-lobed cross section as



# THIN SHEET TAPPING

If you have problems providing tapped holes in thin sheet then read on for some useful ideas, and if you don't, still read on as included is a novel idea for a free source of taps for the purpose!

indicated in the sketch and form the thread by the principle of cold flow of the metal, a method which has many advantages and only one minor disadvantage.

Unfortunately, these types of tap do not appear in any of the catalogues for the recognized suppliers to the model engineer, and are not that easy to find amongst the industrial suppliers either.

The advantages are as follows:

1. The tap, having no flutes, is much stronger.
2. The thread, being cold formed, work hardens and is therefore stronger.
3. An almost perfect thread is formed.
4. The tap forms a slight protrusion both at the front and rear of the thread, thus in effect locally increasing the thickness of the

metal, as a result increasing the strength of the thread. This is particularly beneficial for the thinner sheets, though it can be a disadvantage if this cannot be tolerated and has to be removed.

### Self-tapping screws

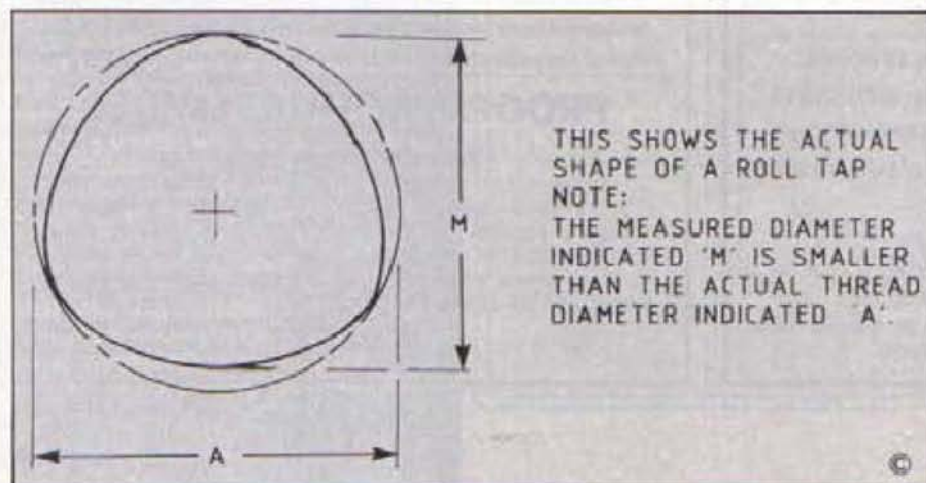
We are all aware of the use of self-tapping screws, particularly those rather like a chipboard screw, and the problems of replacing these if one gets lost during the use of the assembly in which they are fitted, or during service work.

To overcome this problem, self-tapping screws have been developed which produce standard threads, and can therefore be replaced with a standard machine screw if lost. These can take the form of a simple tap probably with just one flute over the first three or four threads; these have the disadvantage that they produce swarf, particularly unacceptable in the electrical industry.

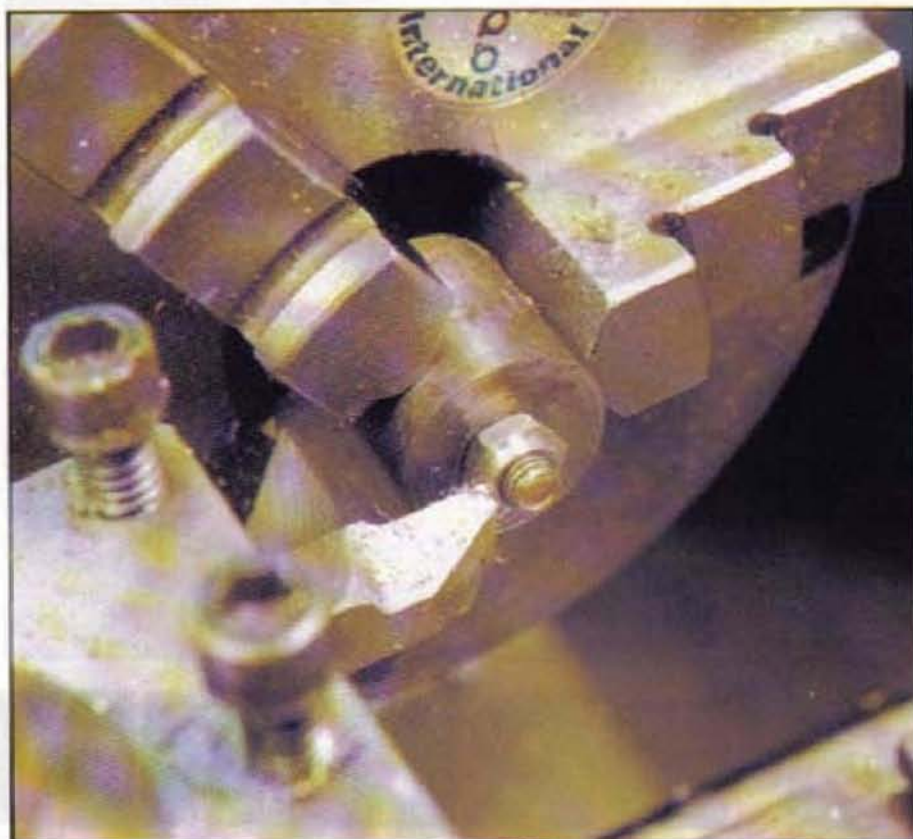
To overcome this problem, self-tapping screws were produced employing the same principle as the cold forming tap. In this form the superior fit between screw and tapped hole means a stronger fixing than normal with a machine screw and conventionally tapped hole, also as the formed thread tends to recover around the three faces of the screw this increases its resistance to loosening under vibration.

### Taptite screws

This form of self-tapping screw, known by the trade name of 'Taptite', can be recognized by it having a slight taper over its first few threads and a tri-lobed cross-section. This can be seen on the largest sizes but can be felt on the smaller sizes by





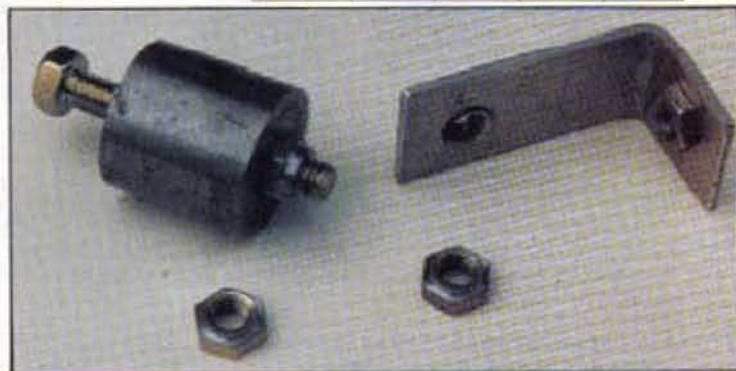


Above, an insert being made from a standard nut.

| Screw Size | MATERIAL THICKNESS |          |          |         |
|------------|--------------------|----------|----------|---------|
|            | 2mm                | 3.5mm    | 6.5mm    | 8mm     |
| M2.5       | 2.2/2.25           | 2.25/2.3 | 2.3/2.35 |         |
| M3         | 2.6/2.7            | 2.7/2.75 | 2.75/2.8 |         |
| M4         | 3.6                | 3.6/3.7  | 3.7/3.7  | 3.7/3.8 |
| M5         |                    | 4.5/4.5  | 4.5/4.6  | 4.6/4.7 |
| M6         |                    | 5.4/5.4  | 5.4/5.5  | 5.5/5.6 |

#### UNC threads

| Screw Size | MATERIAL THICKNESS |          |          |         |
|------------|--------------------|----------|----------|---------|
|            | 2mm                | 3.5mm    | 6.5mm    | 8mm     |
| 2-56       | 1.9/1.9            | 2.0/2.0  | 2.0/2.05 |         |
| 4-40       | 2.5/2.5            | 2.55/2.6 | 2.6/2.65 | 2.6/    |
| 6-32       | 3.1/               | 3.1/3.1  | 3.1/3.1  | 3.2/3.2 |
| 8-32       |                    | 3.7/3.7  | 3.8/3.8  | 3.8/3.9 |
| 10-24      |                    | 4.2/4.2  | 4.2/4.4  | 4.3/4.5 |
| 10-32      |                    | 4.4/4.4  | 4.4/4.5  | 4.5/4.6 |
| 1/4-20     |                    | 5.5/     | 5.6/5.7  | 5.7/5.8 |



Above left, a selection of proprietary threaded inserts. Above right, jig for machining inserts from standard nuts, and a bracket with inserts fitted.

rotating the screw between thumb and forefinger.

A single screw can be used to produce threads many times over, particularly in the softer metals and for this reason can be used in the model engineer's workshop as an alternative to a tap.

If you are dismantling any electrical equipment or similar, look out for these screws you may have a cheap supply of taps; alternatively you may be able to acquire a few samples. K.R. Whiston Ltd sometimes have these in their list of surplus screws.

Tapite screws are made in metric and UNC sizes and the following lists show suggested hole sizes both for steel and aluminium. A little lubricant (not normally used with these screws) will help preserve screws for further use.

Tapping size drills are shown in the tables below the material thickness. Smaller size for aluminium, larger size for steel.

The figures quoted in the tables are those given for use with Tapite Screws; manufactures of cold forming taps do not

give different sizes for varying material thickness, their quoted sizes approximate to those given for 6.5mm sheet.

#### Cutting lubricants

Recommendations regarding cutting lubricants for machine tapping are listed below. These could be considered to be a good guide for hand tapping also. Trefolex is also much used for non-machine use, though when the author was involved in the heavy electrical industry where much machine tapping of aluminium sheet which also had to be bent was undertaken and, as a result, had to be very soft, Trefolex was used extensively for this purpose.

| Material  | Lubricant            |
|-----------|----------------------|
| Aluminium | Light Oil            |
| Brass     | Light or soluble oil |
| Copper    | Soluble oil          |
| Steel     | Soluble oil          |
| Cast iron | Dry                  |

When using cold forming taps a good quality lubricating oil should be used for all materials though, of course, they are not appropriate for use on cast iron.

#### QUICK TIP

The makers of resin adhesive recommend that at least a one inch length of both adhesive and hardener are squeezed from the tube onto the mixing surface, this is to ensure that reasonably equal amounts of each item are dispensed. Most people will get sufficiently equal amounts even if smaller quantities are squeezed from the tube but this can still be wasteful if only a small item is to be fixed.

In this case, take two pins or small nails and remove a small droplet of adhesive from the open end of the tube on the end of one pin and a similar droplet of hardener on the other. It should be easy to judge suitable amounts by this method. The two parts can now be easily mixed by rotating the pins between the thumb and finger, one in each hand, and at the same time holding the ends with the droplets together until an adequate mix is achieved and the adhesive can then be used. By this method wastage will be negligible.

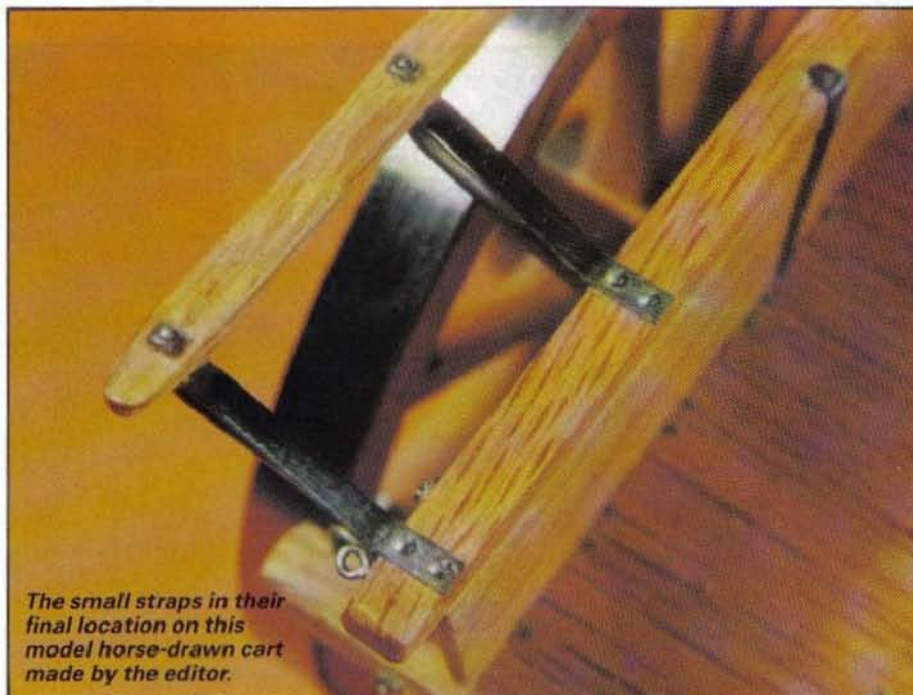


**W**hen in a situation where it is required to drill a number of identical parts, the proper approach is to consider making a suitable drilling jig. However, the temptation will probably be to get out the ruler, scribe and centre punch and mark the part out directly!

If more than one part is involved, then using the first part as a template for drilling the remainder, perhaps with a clamp of some form to hold the parts together, is one method. This may be satisfactory if the part is relatively large and simple, but even in this case the clamps will probably make it difficult to place the part firmly on the drilling machine table.

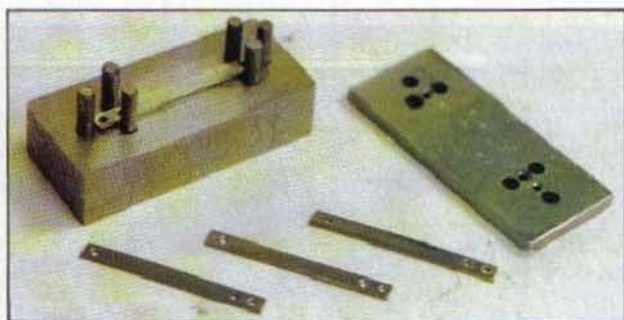
The justification for taking time to manufacture a drilling jig will depend on a number of factors and these should always be borne in mind before proceeding with what may be considered to be the 'normal' method.

If the quantity is large, it may be desirable, no matter how simple the part is.



*The small straps in their final location on this model horse-drawn cart made by the editor.*

# USING DRILLING



*The drilling jig and the small strip parts on which it is used.*

For a very small part it could be considered worthwhile even for a much smaller quantity, in view of the difficulty of both marking out and holding such parts. Another factor could be one of precision as it is much easier to be consistent using a well made drilling jig. And finally, even for one or two off, a jig may be beneficial if the arrangement of holes is complex, such as requiring a number of holes equally spaced on a pitch circle diameter. An instance of the latter would be the top and bottom cylinder end covers and the cylinder itself for a stationary steam engine.

The purpose of this article is not to give specific details for universal jigs such as the various types of cross drilling jig that can be made, but to present some general ideas and to encourage drilling jigs to be considered for that special application, before reaching for the rule and centre punch. [an excellent example of this can be found hidden away in the article on toolmaker's clamps elsewhere in this issue. Ed]

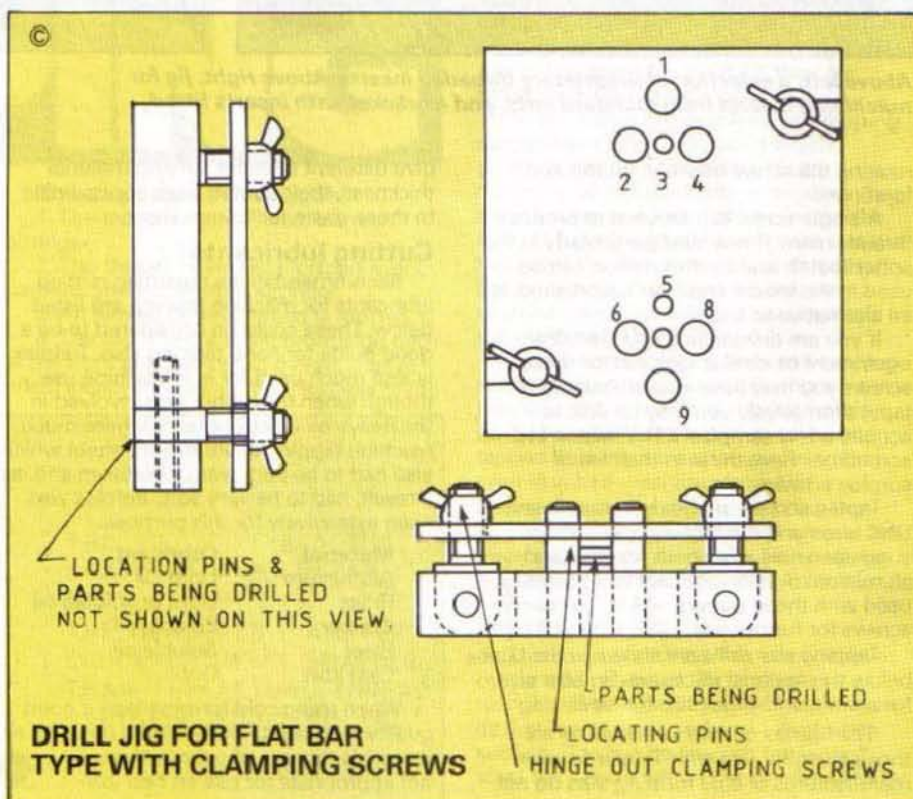
Two situations are to be discussed, the first appropriate to a large number of cases, whilst the second is very specific to the part being drilled.

## Drilling flat plate

In the first we are considering a drilling jig for use with flat plate or bar. This is a

The editor here considers using some production engineering techniques in the form of drilling jigs in the home workshop, the purpose, to improve both the productivity of, and also the quality of the finished component.

This article provides nothing for immediate construction but is intended to encourage the reader to consider the possibility of making a drilling jig for the manufacture of a component, before resorting to the more immediately available methods





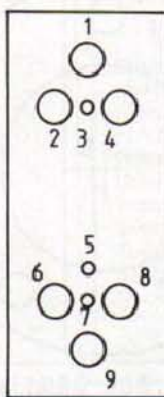
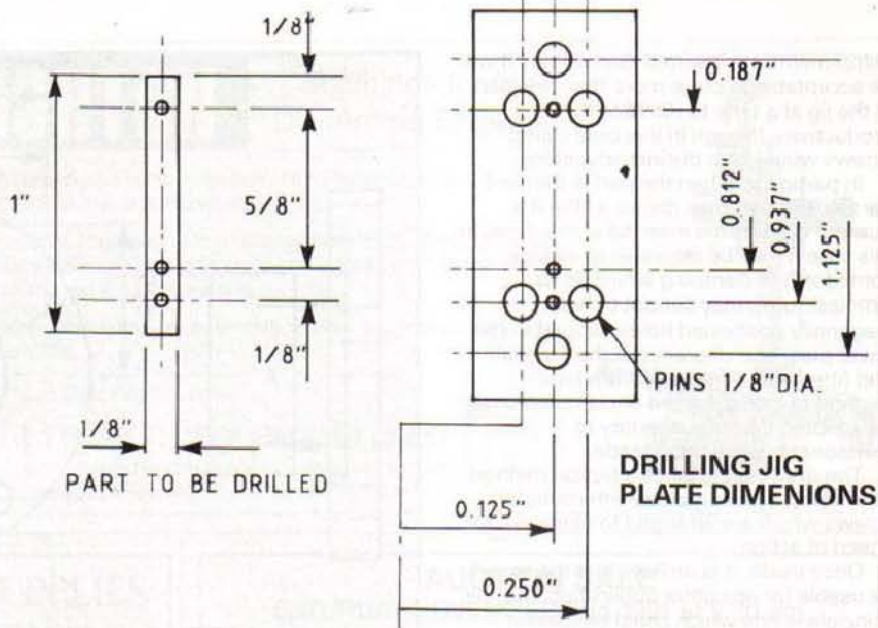
requirement which will crop up many times and the design proposed should be appropriate in the majority of cases.

The actual jig shown in the photographs was used for drilling the metal straps between the bed rave and the barge rave for a model Monmouth cart, and jigs of the same construction were made for similar parts on the same model.

These all proved very satisfactory; for example, out-of-line holes in a  $\frac{1}{8}$  inch wide strip will appear totally unsatisfactory even if the holes are only a few thou off centre, but this can easily be avoided by the use of a simple but well made drilling jig.

The design of jig consists of two plates, a thinner top plate and a thicker bottom plate. The typical drawings show the part to be made; the dimensions for the plate and the hole co-ordinates are shown in tabular form. The dimensions are based on  $\frac{1}{8}$  in. diameter component locating pins.

Both plates are drilled with the same size holes, the  $\frac{1}{8}$  in. holes being a close fit on the locating pins. The holes provided for

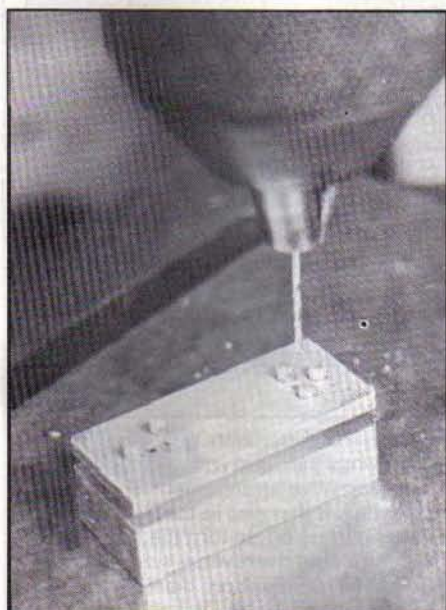


| N° | X     | Y     |
|----|-------|-------|
| 1  | 0.125 | 0.000 |
| 2  | 0.000 | 0.187 |
| 3  | 0.125 | 0.187 |
| 4  | 0.250 | 0.187 |
| 5  | 0.125 | 0.812 |
| 6  | 0.000 | 0.937 |
| 7  | 0.125 | 0.937 |
| 8  | 0.250 | 0.937 |
| 9  | 0.125 | 1.125 |

JIG BORING CO-ORDINATES.

DRILLING JIG FOR FLAT BAR

©



The drilling jig in use.

drilling the actual part would normally be the same size as the holes required in the final component, but in the case of larger parts with large holes it may be preferable to drill with smaller pilot holes and open up when removed from the jig.

The method of positioning the holes will vary depending on the component itself — say, whether it requires to be a precision part or maybe so small that it would be difficult to mark out manually. The simplest method will be to use normal hand marking out tools or perhaps a surface gauge or, for more precise work, a vernier height gauge.

By far the best method is to use the milling machine (or the lathe fitted with vertical slide) as a simple jig borer, and it is with this in mind that the drawing shows the co-ordinates given in tabular form.

For this method the machine is fitted with a centre drill and the top plate held in

a suitable manner. The drill is located in the position corresponding to "x" = 0 and "y" = 0 and the dials on the machine zeroed.

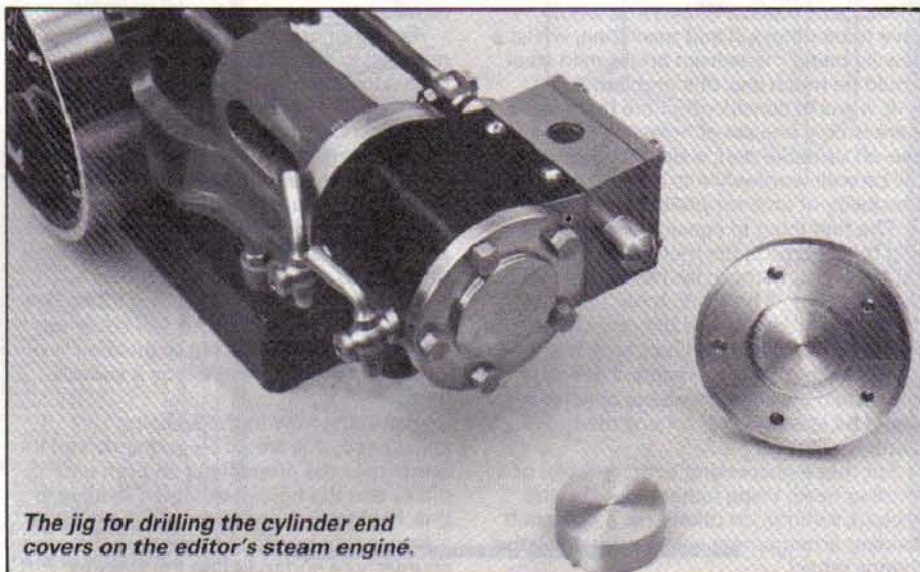
The table is then indexed to the "x" and "y" position for the first hole which is spotted with the centre drill, followed by the remaining holes in turn, again using the leadscrew dials for positioning.

Following this, the holes in the top plate are opened up to size, the top plate is then positioned over the bottom plate and a single  $\frac{1}{8}$  in. hole is drilled through into the lower plate. This is then fitted with a pin and a second  $\frac{1}{8}$  in. hole drilled through and a

further pin fitted. These two holes should be at opposite ends of the jig.

All the remaining holes can now be drilled including those for drilling the component and the full complement of pins fitted. For ease of use, ensure that the pins are a tighter fit in the bottom plate by slightly denting the lower part of the pin with a ball peen hammer and tapping it home. This will make sure that the pins stay firmly in the lower plate when the top plate is removed for changing the component.

When using the jig, always ensure it is brushed clean inside when new



The jig for drilling the cylinder end covers on the editor's steam engine.



components are inserted. Sometimes it will be acceptable to place more than one part in the jig at a time to increase the productivity, though in this case clamp screws would be a distinct advantage.

In particular, when the part is thin and narrow, the part may distort a little if a number of parts are inserted at one time. In this case it may be desirable to include some form of clamping which, in its simplest form, may consist of two diagonally positioned holes, tapped in the lower plate and clearance in the top plate and fitted with screws. A more rapid method of clamping and unclamping could be adopted if a large quantity of components were to be made.

The drawing indicates a typical method for making a jig complete with clamping screws which are arranged to hinge out for speed of action.

Once made, it is unlikely that the jig will be usable for any other application, but the principle is one which could be used whenever a quantity of identical flat parts are required.

Having said that, in the case of the more complex jig complete with clamping screws, providing it could be arranged that the locating pin positions did not clash, this could probably be reused by replacing the top plate only, possibly maybe for a number of different components. In any case, the clamp screws could be used for a number of operations.

If it is anticipated that the jig will be used for a number of applications or if some part is to be made in larger than normal quantities, it is definitely worth also fitting feet below the fixtures as this will make it less susceptible to swarf on the drilling machine table.

## Drilling holes on a pcd

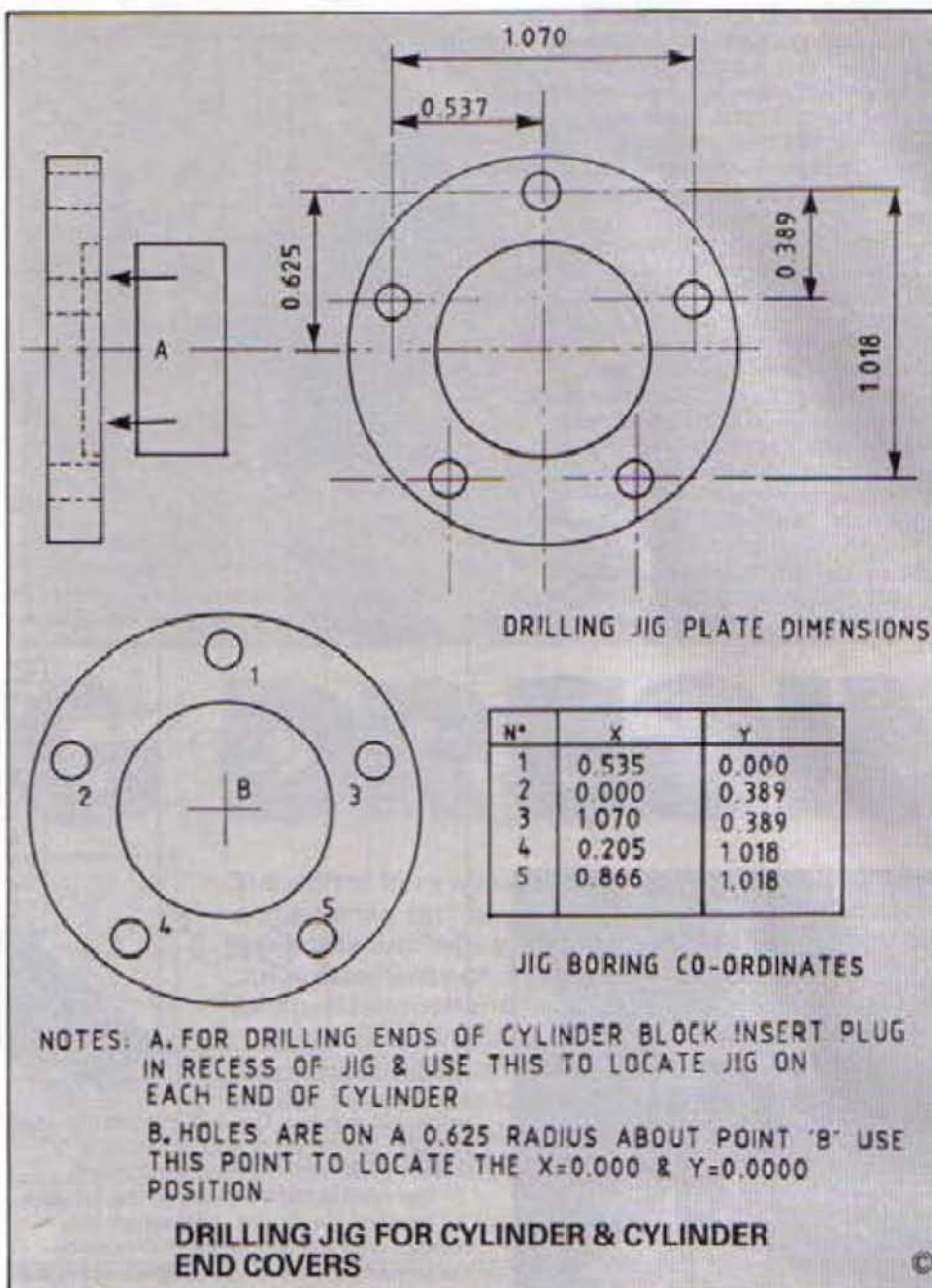
In the second case we consider a jig which is peculiar in design to the application only. Here we require to drill five holes equally spaced around a circle both on the cylinder end covers and the cylinder itself of a stationary steam engine.

Whilst this is required only for four sets of holes it is still much easier than any other method, although it could be considered that it is unnecessary to make this jig as the outer end cover itself could be used for this purpose. However, the disadvantage of using the end cover is that, if it were spoilt during marking out and drilling, a new piece of cast iron would have to be obtained and machined, whilst a new jig being made from bright mild steel would be much less of a problem.

It is worth considering here that even if there is only one set of holes to drill in a one-off valuable part, a simple jig would still be well worthwhile to avoid the possibility of an error on the final part.

The first thing to consider when making a jig of this type is the method of marking out the holes. In this case had it been six holes it could all be marked out using a divider, first marking out the circle, then stepping round this six times with the divider set at the same radius. With care this should give an acceptable result but would be less practical for any other number of holes.

For those possessing a rotary table, or a dividing head, using either would be the obvious solution, or otherwise a makeshift dividing arrangement using a suitable lathe change wheel.



Alternatively, calculating the hole co-ordinates and marking the jig out as in the first example is the only practical solution and quite simple with only a few holes. With five holes in this example it is required only to calculate the position of two holes, as indicated in the drawing, and from this all other positions can be determined.

For other quantities of holes it may be required to calculate each position, very time consuming but maybe the only way. In this case all calculations should be checked before proceeding.

If making any form of multi-hole device with holes equally spaced on a given diameter by the method of calculating co-ordinates and drilling each hole from these, and if the accuracy is critical, then consider drilling two plates at the same time.

On completion, separate and rotate one plate against the other. This will show up clearly any hole that is out of position which can then be rectified by a suitable method.

Returning now to the jig being considered, this would be counterbored to locate over the projections on both end plates and the holes positioned relative to this. For locating on the end of the cylinder, a plug would be made to insert in the counterbore and to fit into the cylinder

bore; these requirements can be seen from the drawings included with this article.

An alternative arrangement, if you can reliably hold a thin disc in the lathe, would be, after parting off, to turn the disc round and to turn onto the reverse side a spigot, equal to the cylinder bore diameter.

Having made the jig, drilling the four sets of holes will be considerably easier than by any other method, and as a result well worth the small amount of extra effort required to make it in the first instance.

## Conclusions

To sum up, making a jig will be worth considering for a number of reasons. The first and most obvious is to save time; another is to make a difficult job easier. In some cases it may be to improve the accuracy of the final part and in a few cases to avoid the initial work having to be done on an expensive component, which may have to be scrapped if an error is made.

Bearing these facts in mind and making suitable jigs as appropriate will improve the efficiency of the model engineer's workshop either in time taken, quality of part made, or both — a consideration which should be equally at home here as in the professional situation...



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Specification H510

Motor  
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Depth of Cut (90°) 80mm (3 1/8")  
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Graduated Blade Tilt 0-45°  
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### Specification H510

Motor 185w (1/4 HP)  
240v Induction Type  
Table Tilt 45°-0°-10°  
Table Size 290mmx240mm  
Throat Size 250mm  
Depth of Cut 120mm  
Speeds (RPM) 440, 1725, 3420rpm  
Overall Dimensions 550 x 450 x 575mm  
Weight 15.3 KGs

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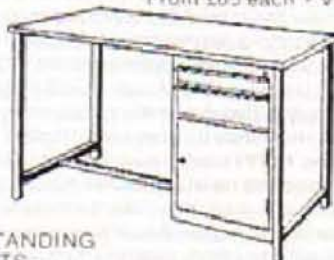
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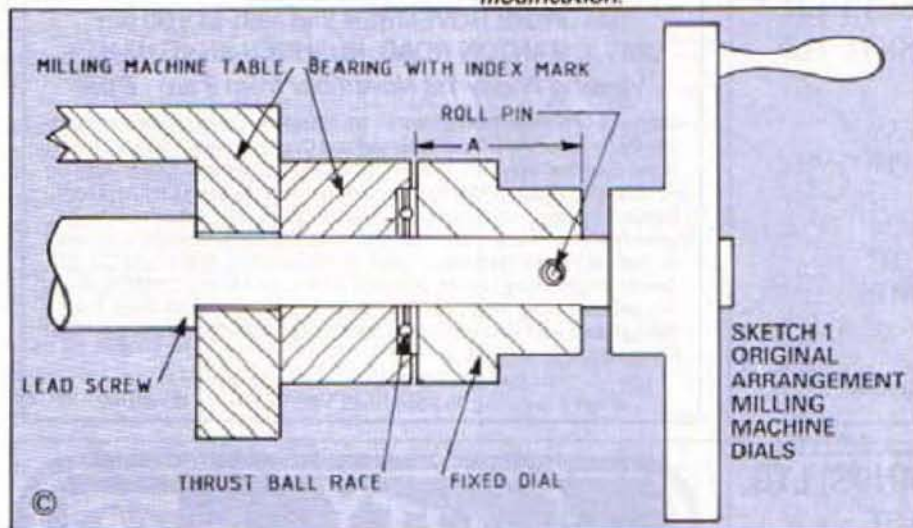
# MILLING MACHINE DIALS

Operating a machine with fixed index dials can be quite difficult and easily lead to errors, particularly in the case described here where the milling machine had dials calibrated 0 - 125 thou rather than the more acceptable 0 - 100 thou.

This article suggests a method for modifying these to the more convenient friction dials



The standard dial, before modification.



SKETCH 1  
ORIGINAL  
ARRANGEMENT  
MILLING  
MACHINE  
DIALS

Trying to operate a milling machine having fixed index dials is difficult enough with a ten threads per inch leadscrew and calibrated 0 to 100 thou, but if it also has an eight threads per inch leadscrew and calibrated 0 to 125 thou, then it becomes doubly difficult!

Faced with this situation modifying the dials to be friction fitted seemed essential. Initially it was intended to modify only the leadscrew dials, as these were the most used, and the downfeed dial left fixed — even though this was calibrated 0 to 140 thou. Subsequently this was modified also.

It is appreciated that the present-day Far Eastern machines do now have friction dials and 10 TPI leadscrews but even so there must still be many earlier machines which have this problem. As there were, and are, many makes available the precise design will vary from machine to machine, but no doubt the method proposed here could be adapted to suit.

## Original design

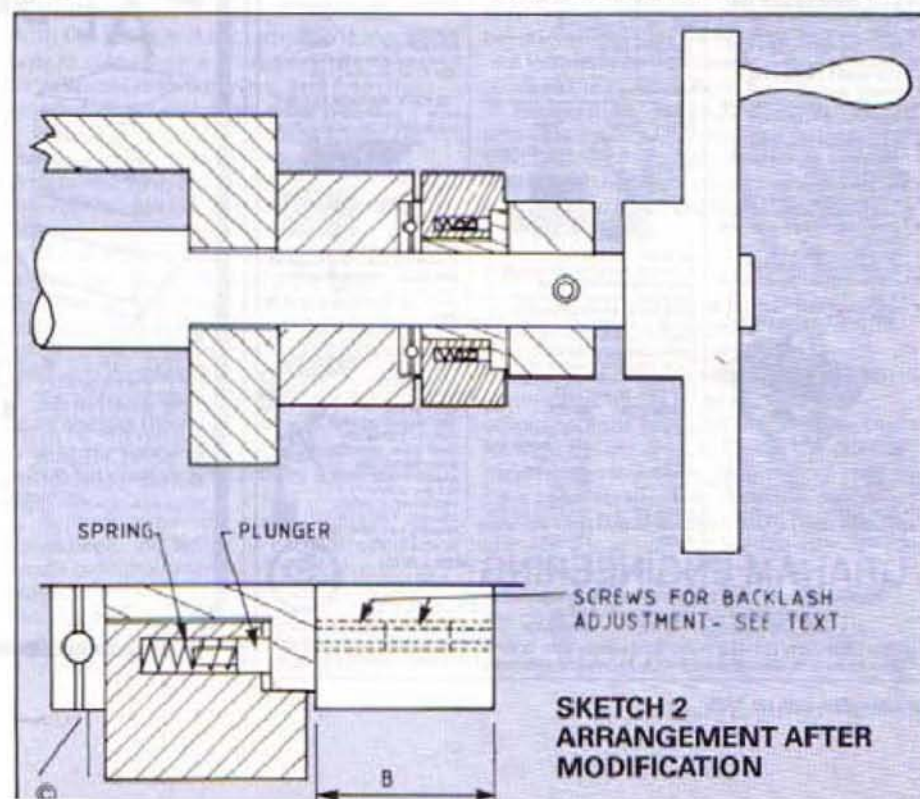
The original design can best be seen in Sketch 1; the dial itself is fitted to the leadscrew using a sprung dowel pin (roll pin) and the end thrust is taken by it also, via the thrust race shown.

The depth of the recess housing the thrust race is arranged such that the gap between the bearing housing, marked with the index line, and the dial is a few thou only, essential for easy reading of the dial position.

No adjustment is available to minimize

backlash as the thrust face in the other direction is a solid face turned into leadscrew itself as can be seen in the sketch.

Backlash in the bearing (there will be additional backlash between leadscrew and nut) is therefore dependent on the original positioning when the sprung dowel pin is fitted.



SKETCH 2  
ARRANGEMENT AFTER  
MODIFICATION

## Modified design

The modified design is shown in Sketch 2. This shows how the dial has been cut from the portion pinned to the leadscrew and bored out to take an additional bush. A flange is incorporated into the new bush and this acts as a friction surface for the spring-loaded plungers also added to the dial.

It can be seen that the internal bush is in no way fixed to the leadscrew and this is acceptable only on the basis that the design has a thrust race fitted. If this had to bear against a fixed surface to take the thrust it may rotate on the leadscrew and take the dial with it, thus creating errors in the reading.

To avoid this the design would require modifying as in Sketch 3 and the bush would have to be fixed using a grub screw, as is shown in the part drawing. Also in this case a washer of suitable thickness would have to be fitted to ensure the dial remained close to the bearing, but not touching.

Whilst not included in the original modification, adjustment for endplay could be incorporated by the addition of screws fitted into the fixed boss to bear on the end of the friction bush. These can be seen in Sketch 2; two grub screws would be fitted in each position, the first to achieve the adjustment, the second fitted after adjustment is complete. This to lock the first in position.

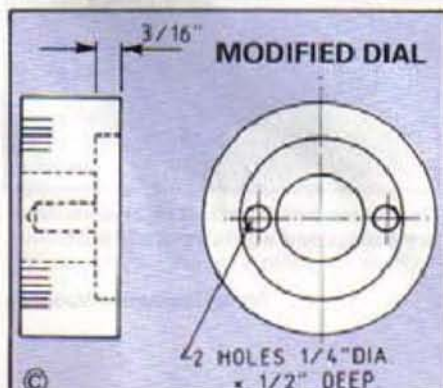
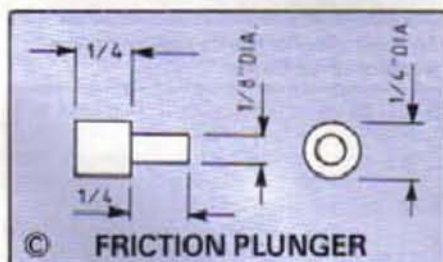
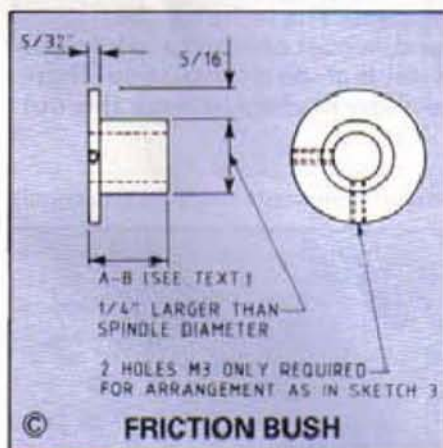
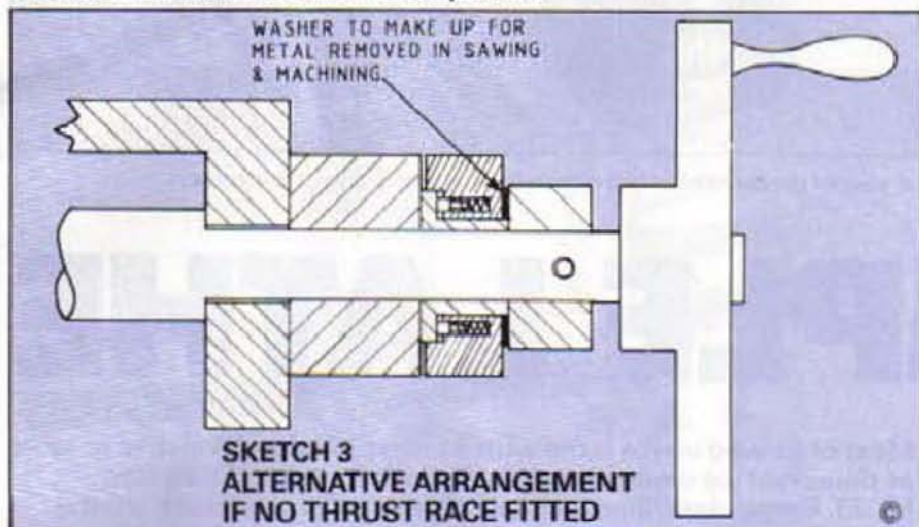
## Construction

First measure the length of the dial with bush (length A) using a micrometer to get a precise dimension. Now carefully hold the dial in the vice with some protection to avoid damaging it and, using a hacksaw, cut the dial from the boss as close to the





The modified dial and the additional components.



dial as is possible. Now face both the boss and the dial to remove the saw marks.

Measure the length of the boss (length B), again using a micrometer and subtract this value from that found previously for the overall length. This will give the length required for the bush to be made and this dimension is crucial if no adjustment is to be included. If it is intended to provide adjustment as suggested, then make the bush, say, five thou shorter than the calculated value.

Making the bush should present no problems but do make certain that the bore is a close fit on the leadscrew extension and that the length is as calculated. The two outside diameters are not critical as the dial can be bored to suit.

Place the dial in the four-jaw chuck using some hard cardboard or similar to prevent it getting marked, and adjust so that it is running true. Do ensure that it is in the correct way round for boring both diameters — take note that it is reversed if you have no thrust race and are proceeding as in **Sketch 3**.

Make both bores a close fit on the bush already made, especially the smaller of the two, but even the larger will benefit from being a close fit as this will help to prevent the entry of dirt into the friction surfaces.

Drill the two holes for the spring-loaded

plungers and to a suitable depth for the springs available. Make the plungers also, assemble the dial, bush, plungers and springs in the hand to ensure that everything is satisfactory before assembling onto the machine.

Drill and tap the bush which carries the sprung dowel to take the backlash adjustment screws, and whilst it was suggested earlier that this could be considered optional, it is worthwhile adding this facility.

On final assembly some adjustment to the friction may be considered worthwhile and this can be achieved either by varying the length of the plunger or the spring. Both leadscrew dials can be modified in the same manner and will be found a very worthwhile modification greatly easing the operation of the machine.

### Downfeed dial

Having originally decided that the downfeed dial would not be modified, but considering the leadscrew dials a major success, it was decided to investigate the matter further.

On dismantling, it was found that the dial was simply held with a grub screw, and was in no way used to provide any form of end thrust. As a first idea it was considered placing a small plug of rubber below the grub screw and partially tightening; this was not tried as it was considered it would not work well, and would tend to turn back a little when released, due to the sideways pressure that would be exerted during turning by hand.

It was then spotted that a groove had been turned in the spindle, the purpose of which was obviously to avoid the dial becoming trapped, due to burrs being thrown up when the fixing screw was tightened. Fortunately, this groove was deeper than necessary and could easily house a short leaf spring that would achieve the desired result.

The ends of the spring were shaped as shown in the sketch to avoid these digging in, and the unit assembled. The ends of the spring were held between the jaws of a pair of pliers and pressed together whilst it was held in position in the groove. This enabled the dial to pass over it, and the result was a very easy and also a very effective solution to the problem.

The omission of the dial-fixing screw could be tolerated as endways movement was limited by the bearing housing on the one side and the hand wheel on the other.

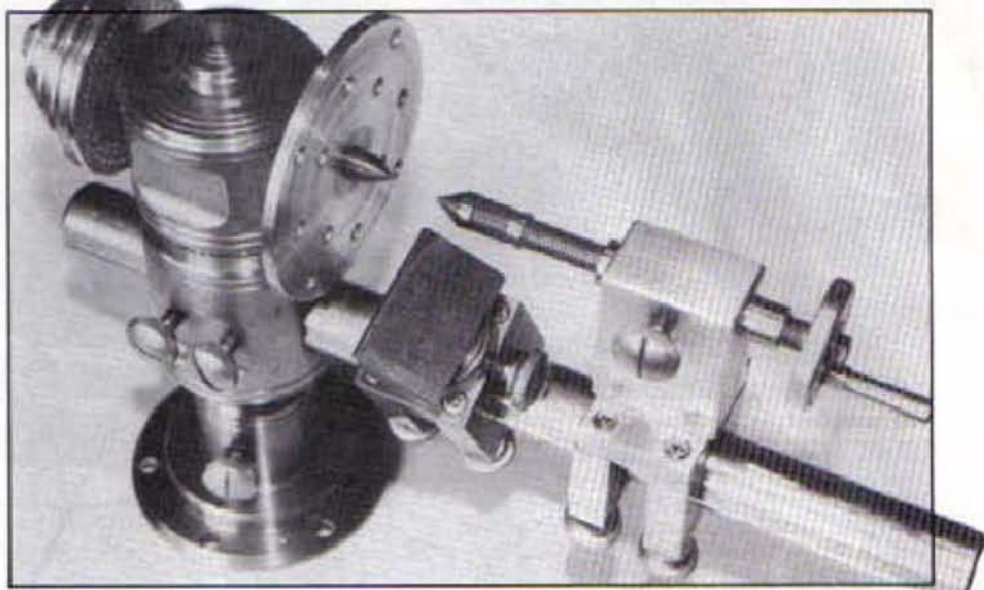
These modifications provided a very satisfactory improvement to the machine, and one which would have prevented the writer starting design and construction of a digital read-out had he done this earlier! Even so, the two axes digital read-out has proved very effective, when eventually completed, was also a very rewarding project, and in any case the two seemed to complement each other. *(The digital read-out will be featured in a major article soon. Ed)*





**T**his article describes the construction of a lathe which does not involve castings. It is fabricated almost entirely from available round-stock and, although basic by comparison with the average modeller's lathe, is nevertheless capable of a good performance using handheld tools. The lathe is a little larger than the average watchmaker's type, which it closely resembles, and there is no reason why the design could not be 'up-scaled' with a larger diameter bed and headstock.

Three speeds are available, with a pulley cluster mounted in a swing frame, which is used to adjust belt tension between the lathe and the countershaft. Adjustment of the second belt, between the countershaft and the electric motor, is arranged by moving the motor. Ball-bearings are used in the headstock, and the method of installing these with the head spindle is described in the text, as is the method of accurately boring the locations for both the spindle and the round bed. The material used in the lathe described was solid brass, for the following reasons. It is easy to machine, it has good appearance when finished, and it



*A view of the completed lathe, seen here with the faceplate attached.*

# A SIMPLE LATHE

tends itself readily to nickel plating should this be desired when completed, and this is a finish often used with watchmaker models. Alternatives are mild steel or even aluminium, at least for the headstock assembly.

**YOUR FULL SIZE  
PULLOUT DRAWINGS**

The motor should be at least  $\frac{1}{2}$  horsepower or better; sewing machine motors are just not strong enough for the job, although they can be used for more delicate work in brass or aluminium, and for polishing etc. On the other hand, the motor should not be so strong as to cause vibration. I used a  $\frac{1}{2}$  horsepower ex-dental electric motor having about 2,500 rpm, and

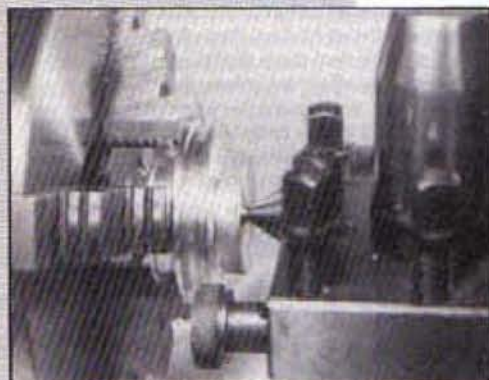
Most of us who own a lathe with a centre height of 3 inches or more at times feel we would like a smaller one for those fiddly bits. Mr J.T. Bergin described a simple method of making such a lathe but sadly died before it was published; we are grateful to Mrs Bergin for allowing its use in the magazine. The lathe can be adapted to suit available materials and, whilst complete in itself, for the use of gravers the lathe does not include a cross slide. There are, however, sufficient details to allow readers to work this out if they wish

this gave speeds of approx 800-500-300 rpm with the pulley cluster sizes used. The cluster for the headstock spindle was machined from solid aluminium, as was the countershaft cluster, but in this case the larger 'V' pulley was machined from thick aluminium plate and press-fitted onto the three-pulley cluster after knurling the spigot. The countershaft is carried on small ball-bearing assemblies, their outer sections rotating with the cluster. (An opposite approach to the headstock, where the inner sections rotate.)

It will be seen that only one support or 'leg' is used, and this also follows watchmaker example, where such design enables the lathe to be rotated away from the front of the bench when not in use. However, a second support can be added if desired. In this case, the whole assembly was mounted on a 12 in. x 10 in. chipboard base, making a portable unit which could be used anywhere within reach of a power point. Although lathes of this sort lack many of the refinements of larger models, they are very useful for small jobs and for miniature grinding, where the abrasive wheel is held in the chuck on the headstock. A faceplate is incorporated, and this is screwed onto the spindle nose in the usual manner, as is the Jacobs type chuck shown, also a small 3 or 4 jaw conventional chuck, (not shown).



*Another view of the completed lathe, without drive frame.*



*Knurling the spigot before press-fitting to large pulley in countershaft.*



*Rear view; two identical electric motors are being used experimentally here.*



## The headstock

The headstock is in two parts, bolted centrally together by a cap screw, a feature which allows adjustment between the spindle and the round bed. Part 'A', the top part, carries the spindle assembly, whilst part 'B', the lower half carries the bed. These two parts are fitted together in a manner similar to the fit of a chuck and its backplate, the large annular surface contact providing a non-slip mating area. Each part, i.e. 'A' & 'B', should be dealt with in turn, completing one before starting the other. In this way the second part may be machined to fit the first. With the two parts thus fitted together, the assembly is set up on a surface plate with the round bed in place, and a test bar fitted into the headstock spindle bearings providing an extension of

recommended that the  $\frac{1}{2}$  in. cap screw be removed and a weight placed on top of part 'A' to hold it on its seat with part 'B'. (It is assumed that only part 'B' will be altered.)

It is not denied that this is a somewhat difficult procedure, but being forewarned may make us more careful with the preceding machining of the two parts in the hope that very little metal will need to be removed. In any event, it is essential that the two faces finish with a true bearing, one on the other; no 'rock' can be tolerated here.

Assuming the foregoing operation has been successful, we now replace the cap screw to lock the two parts together, and then set it up again on the surface plate (mine is 12 in. x 12 in. plate glass, 10mm in

## Machining part 'A'

Concentrating therefore on part 'A', we refer to the drawing of it for dimensions overall and, in particular, to the spindle centre-to-bed measurement. Although not critical, this latter distance must be such as to allow space for the 'T' rest assembly, based upon dimensions given for it which will allow the top of the rest to be at spindle centre height.



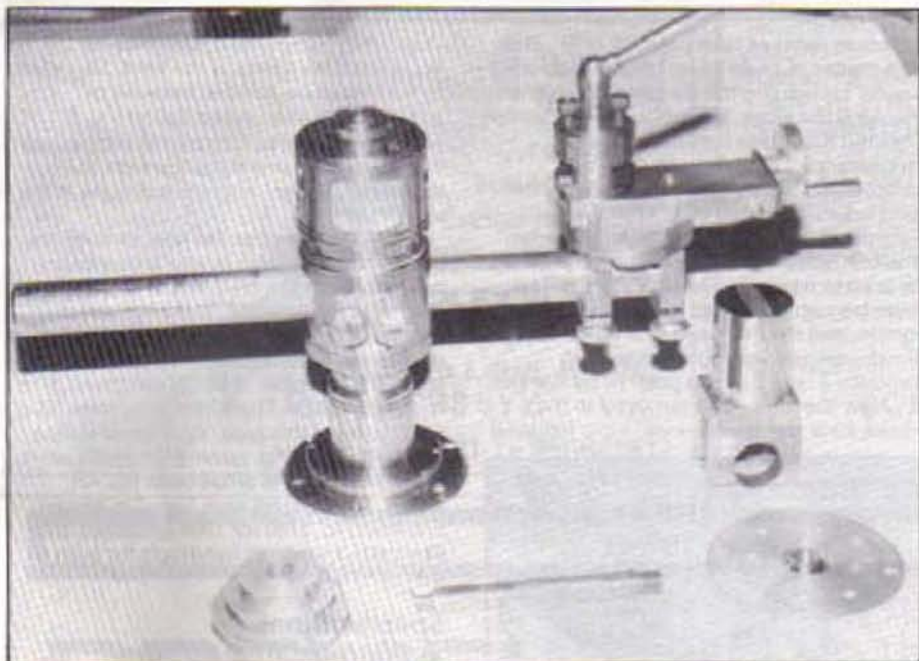
*The countershaft cluster; boring the recess in pulley cluster for ball-races.*

So we machine part 'A' to the dimensions given, allowing enough material to be removed from each face to bring them square with the O/D, as shown with an accurate try-square. This is probably best done in a good chuck, if the available one is large enough, otherwise it can be a faceplate job.

With part 'A' running true in the chuck (or faceplate), we face and machine the outer face as shown in the drawing. This is to be its mating face with part 'B', but the other end face is not so critical, it is merely the 'ornamental' top of the headstock, and can be dealt with later.

Also, before removing from the chuck, a truing skim over the diameter should be taken, and the face centre-drilled and tapped for the  $\frac{1}{2}$  in. cap screw, as shown in the drawing.

When we are satisfied with the squareness and dimensional accuracy, the job can now be mounted in a vee block on the surface plate for marking out of the spindle bore. With the job on its side, we proceed to scribe it all round at exact centre height, using a scribing block. That done, part 'A' is now set up on its mating face on the plate, and scribed all round its circumference at the position decided for the spindle centre. Where this line crosses the first scribed line will be the two centre



*During assembly; the incomplete tailstock is seen at middle right.*

the spindle for test purposes. With the end of the bed supported on an adjustable jack, the bed is made to be parallel with the surface plate, using a DTI (Dial Test Indicator). Now the spindle test bar is checked for parallel, again using the DTI and this simple operation can be done with much accuracy, the central cap screw being finally tightened when all is well. After a final check, the two mating edges are then line or dot marked and the assembly set up for a check in the vertical position.

This involves a similar procedure, except that now part 'B' is positioned on its bottom face and the far end of the round bed, supported by the jack, is adjusted for parallel along its length, with a DTI.

All being well, the DTI is moved to check the test spindle for parallel. If the machining of parts 'A' & 'B' have been true, the spindle should be very close to parallel, but if it is not, then our first real difficulty has arisen. Some correction will have to be made to the mating face of either part 'A' or 'B', but not both. This will take the form of removing a few thousandths of an inch from either the front or the back face in order to lower or to raise the test spindle at its far end, depending upon the reading given by the DTI. As this will involve separating the two halves for a 'scrape and try' operation - always tedious - it is

thickness), finally tightening the cap screw after repeating the first DTI test described above.

Although the above procedures are out of sequence, this has been described first to stress the importance of accurate machining of parts 'A' & 'B' and to highlight the consequences of failure to do so.



*'Exposed' view of some of the components prior to assembly.*

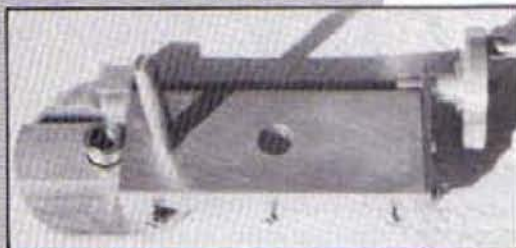


positions of the spindle axis, and these points are now centre-punched and centre-drilled.

Part 'A' is now ready to be bored for the spindle and its ball-bearing races, and it was decided to mount it on the cross-slide using a circular adjustable packing ring as shown in the photograph. This ring was drilled and tapped  $\frac{1}{2}$  in. NF for six screws, although only three are used at any one time, ensuring 'rock-free' adjustment. First, however, the job is 'suspended' between two lathe centres for a true axial position, then the circular packing ring placed underneath to support it after adjustment of the three screws. Finally, the whole was bolted down to the cross-slide using an overhead frame clamp after strips of paper had been inserted between the metal to metal surfaces for a better grip.

That done, a new  $\frac{1}{2}$  in. pilot drill is held in the chuck and the job drilled all through using feed pressure from the tailstock, and the success of this operation can be seen when the drill point breaks through, by checking with the tail centre. Drilling then followed with several larger drills to finish with a  $\frac{1}{2}$  in. size. The final drill should be carefully ground to ensure accuracy. The  $\frac{1}{2}$  in. size is chosen as clearance for the spindle diameter.

The next operation is to bore the two recesses for the ball-bearings, and for this, part 'A' is mounted on a tapered  $\frac{1}{2}$  in. stub mandrel.



**The slide assembly showing the socket-head clamp-bolt and access hole in the slide.**

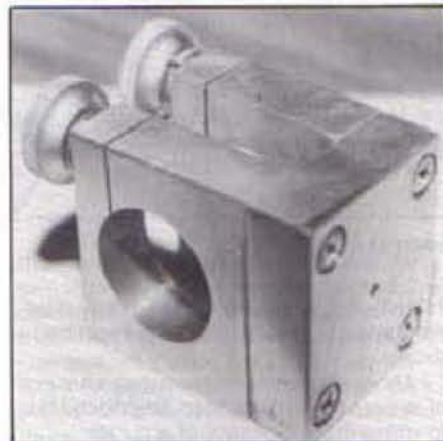
This is a short mandrel, turned for the purpose and left in position in the chuck to receive part 'A'. The taper is very slight, just enough to tighten into the  $\frac{1}{2}$  in. hole without protruding, to allow clearance for the recess. The diameter of the recess is made a light tap fit for the ball-race, but this is not installed until after the other end has been bored. With this done, the job and the mandrel can be removed; the job rechecked for a few 'cosmetic' rings lightly turned on the circumference, after which the two ball-races are installed to a light tap fit in their recesses. (Actually, an extension test spindle was used as a guide when installing the two bearings. This was made a tap fit so that it could be removed later, when the machined spindle was fitted.) Spindle details are shown in the drawing. Silver steel can be used, and drilled  $\frac{1}{2}$  in. to full depth of a standard jobbers drill, from each end to avoid brazing an extension to the drill. Also, the spindle nose is tapped  $\frac{1}{2}$  in. inside whilst in the chuck for its outside nose threading, which was made  $\frac{1}{2}$  in.  $\times 20$  TPI.

The spindle is made a light tap or press fit into its ball-races, the cone pulley assembly lightly pressed on, its grub screw tightened and the retaining nut & washer installed.

With 'A' completed, on the prototype lathe two large flats were shaped on

opposite sides of both parts 'A' & 'B'. This is a matter of preference, but the flats are useful for holding the part in a vice without marking the sides. (An independent opinion insisted that these flats improved appearance!). Now for part 'B'. The procedure for boring the 1 in. hole for the bed is similar to that of 'A' with the exception that, after drilling  $\frac{1}{2}$  in. diameter, the drill is removed and a boring bar set up to bore to one inch diameter exactly. The bore bar can be supported by the tailstock centre, and the one used was adjustable. Finally, several very light passes will produce a hole that is a push fit for the bed.

Now the job can be removed to the chuck for a few appearance rings, followed



**Tailstock base and brackets, complete and assembled.**

by drilling clearance for the  $\frac{1}{2}$  in. cap screw. As seen in the drawing, clearance for the head of the cap screw must also be drilled, usually with a  $\frac{3}{8}$  in. drill which provides a shoulder for the screw.

Part 'C', which is the pillar on which the headstock rests, is also drilled clearance for a  $\frac{1}{2}$  in. bolt through its centre.

This bolt screws into the base of part 'B', which is threaded to receive it. As clearance exists at the base of the pillar for a hex head bolt, this can be used instead of a cap screw in this position.

### Part 'D'

Reference to the drawings will supply details for Part 'D' which is straightforward. Where thumbscrews are shown, short brass pads are first installed in most cases, and these should be a free sliding fit to avoid jamming in the hole.

The faceplate was made from  $\frac{1}{2}$  in.

**The packing gadget or circular jack; packing height is 'miked' over screws.**



duralumin plate, drilled clearance for  $\frac{1}{2}$  in. bolts, used with nuts at the back. Threaded holes should be avoided because of possible distortion when tightening. A brass boss is press fitted at the centre, and this should be lathe threaded to fit the spindle nose, final truing being done in the workshop lathe.

It will be seen that the hole through the centre of the toolrest holder is continued down through the platform, and this allows clearance for a longer 'T' bar rod which may be necessary when the 'T' rest is angled away from vertical, for example, when the faceplate is being used with a wide workpiece. There are many uses for a small lathe of this type, such as miniature grinding, polishing, turning, small file work, hacksaw cutting of small bolts etc. An article, "Hand Tools save Time" in *Model Engineer* No. 3780 for 1986 describes and illustrates a range of handtools for such a lathe as this.

### Specifications

- Spindle centre to bed top .63mm
- Bed. 1 in. (25.4mm)  $\times 12$  in. (305mm)
- Bed brackets. 44  $\times 38 \times 13$ mm
- Part 'A' 63 Dia.  $\times 54$ mm
- Part 'B' 63 Dia.  $\times 72$ mm
- Pulley clusters ( $\times 2$ )
- No. 2.65mm
- No. 3.50mm
- No. 4.40mm
- No. 1 Large pulley dia. 100mm
- Spindle Length o/all.115mm
- Spindle Dia. (To suit bearings)
- Dia. over nose flange.15mm
- Nose thread.  $\frac{1}{2}$  in.  $\times 20$  TPI
- Spindle tail thread.  $\frac{1}{2}$  in.  $\times 25$  TPI
- Spindle nose inner thread (optional)
- .10mm  $\times 25$  TPI.
- Faceplate.4 in. (100mm)  $\times \frac{1}{2}$  in. (6mm)
- Drilled 12 holes  $\times$  clearance for  $\frac{1}{2}$  in. bolts with nuts at rear.

### Materials

- Parts 'A' & 'B'. Solid brass (pref.)
- Bed. Steel.
- Faceplate. Duralumin W/Brass Boss.
- Grub screws. Steel
- 'T' Rest. Steel
- Thumbscrews. Commercial or fabricated.

(The text for this article is limited largely to the headstock assembly; the toolrest, tailstock and motor assemblies are included in the drawings, and ideas for a slide assembly can be seen in the photographs. Ed)





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Ivan Law of Eckington, Sheffield has put forward some very interesting facts regarding the fixing of cutters into their holders and, in particular, into boring bars — points which we should take note of, as they are likely to be of benefit to us all at some time

One of the articles in the April/May issued of *M.E.W.* discussed the subject of boring and, in particular, boring bars. It was a comprehensive article, pointing out what boring is and how it is used to produce true and round holes. These further notes on the subject are not intended to criticise what was said but rather to add to the advice given.

There are two distinct types of boring tool: the one-piece tool made from a single

pinch screw is the Allen socket grub screw, there are occasions when this must be shortened to such an extent that the result is only a tube!

Assuming that an adequate screw can be accommodated, that is not the end of the problem, the act of tightening the screw usually moves the cutter. It is of little use carefully measuring the cutter projection in order to bore to a specific size if, on tightening, the screw moves the cutter.

After one such experience in the dim and distant past the author 'downed tools' in order to give the matter some thought. When things go wrong it is always advisable to go back to basics to look at the problem and if the problem can be fully understood then finding a solution will be made easier. Things are often taken for granted when in fact we should not do so.

In this case the assumption was that the pinch screw secures the tool in the bar when, in fact, it does no such thing. What the screw does is to apply a load on the tool and force it hard against the face of the hole diametrically opposite the screw, see Fig. 1. It is the friction created between the two mating faces that prevents the tool from moving. However, when the pinch screw first makes contact with the cutter,

# CUTTER CLAMPING IN BORING TOOLS

piece of tool steel, and the boring bar where a separate high-speed tool bit is secured into a mild steel bar or holder; these notes deal solely with the latter.

## Problems

I have made many boring bars of all shapes and sizes including those shown in the article, but initially I found that they all suffered in varying degrees from one problem, the actual securing of the tool in the bar. The generally accepted method is to drill and tap a hole in the boring bar in such a position as to intersect with the 'tool hole' and then secure the tool by means of a pinch screw. It is this screw that can give rise to a problem.

Often, the amount of material available for the tapped hole is, to say the least, limited and only a few threads may be obtained for the pinch screw. This results in the threads quickly stripping or, if this does not happen and the tool can be persuaded to stay in the required position, under load and particularly with interrupted cuts the screw may come loose with unfortunate results to the workpiece.

If, in order to obtain more effective threads, a small diameter pinch screw is used, it is then difficult to obtain sufficient load to secure the cutter adequately.

Probably the worst case is in a blind hole boring bar where, owing to the necessity of placing the cutting tool as close to the end of the bar as possible, there is even less room than usual for the screw. In this case the problem is compounded by the fact that the screw itself must not project far from the end surface of the boring bar otherwise it may interfere with the end wall of the blind hole being bored. The result can be a very short and impractical screw. As the best type of

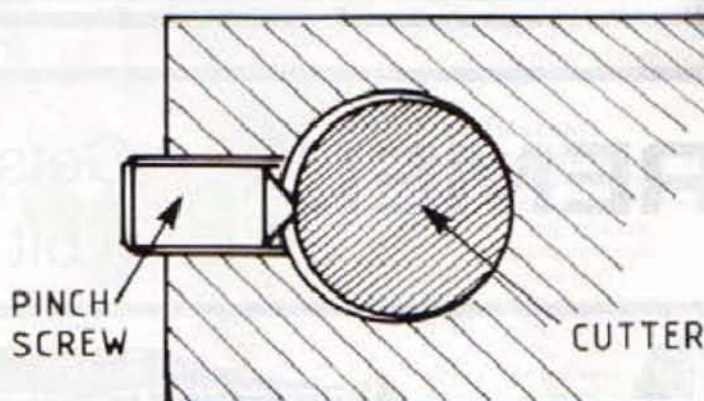


FIG. 1. PINCH SCREW FORCES THE CUTTER ONTO THE BACK FACE OF THE HOLE. THERE WILL BE A SMALL CLEARANCE AT THE SCREW SIDE OF THE HOLE.

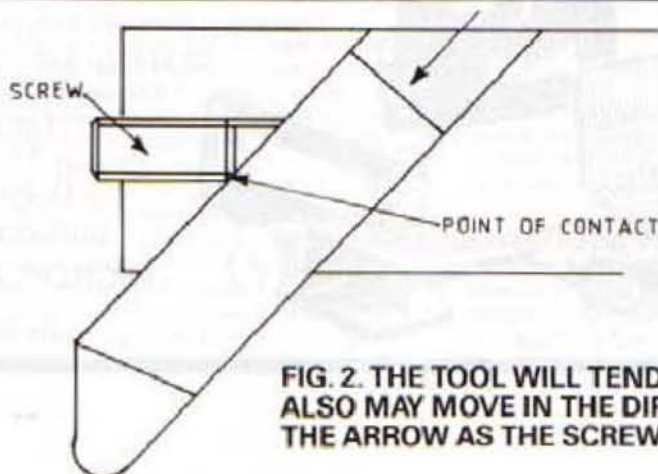
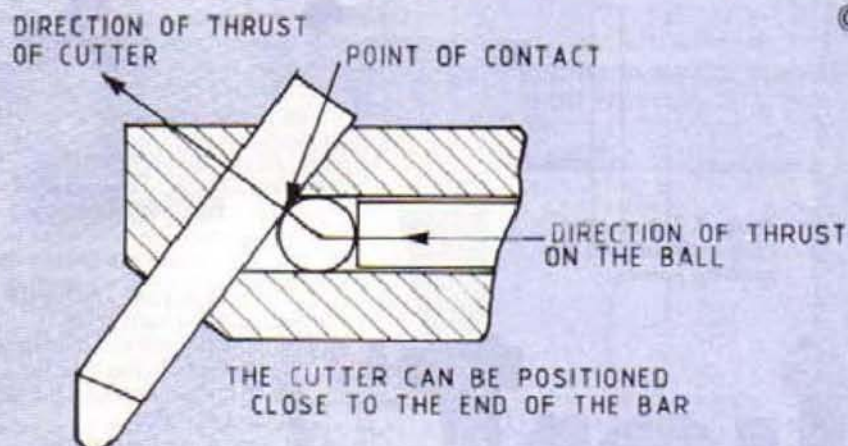


FIG. 2. THE TOOL WILL TEND TO ROTATE & ALSO MAY MOVE IN THE DIRECTION OF THE ARROW AS THE SCREW IS TIGHTENED.





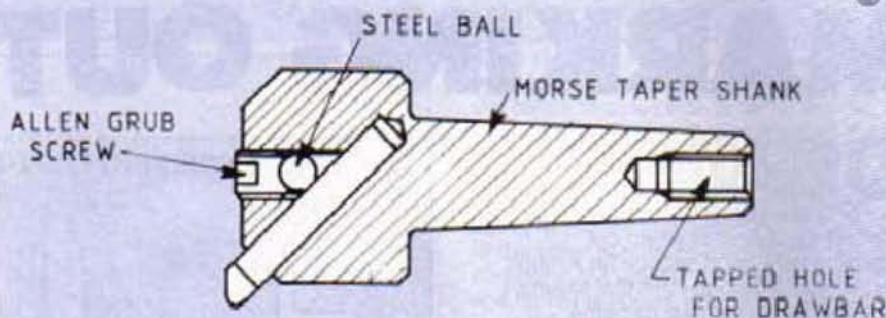
**FIG. 4. SHOWING THAT THE THRUST ON CUTTER IS AT RIGHT ANGLES TO ITS CENTRE IRRESPECTIVE OF ITS ANGULAR POSITION.**

and before sufficient load can be applied to provide a serviceable lock, the actual rotation of the screw induces another force upon this cutter and it is this force that moves the cutter during the locking process. If the pinch screw is not at right-angles to the centre line of the cutter, there will be yet another force acting on the tool and this will tend to move the tool axially in the direction of inclination of the screw, see Fig. 2.

### The solution emerges

Once all the above facts were realised the solution began to emerge. First of all the screw must not be allowed to come into direct contact with the cutter; this can be achieved by placing a pressure pad between the screw and the cutter and so eliminating the force on the cutter due to the rotation of the screw. Secondly, a secure grip of the tool does not depend on plastic deformation of the newly introduced pressure pad and so this pressure pad may be hardened and also, since it is only applying a load, the area of contact between pressure pad and tool need only be small. Elimination of the end load due to any angularity between pressure pad and the tool can only be achieved by always ensuring that the induced force from the screw is at right-angles to the centre line of the tool irrespective of the angle of the screw.

The solution to all these conditions can be met by simply placing a hardened steel ball (often erroneously referred to as a ball



**FIG. 5. SECTION THROUGH FLYCUTTER FOR DIRECT MOUNTING IN EITHER LATHE OR MILLING MACHINE SPINDLE.**

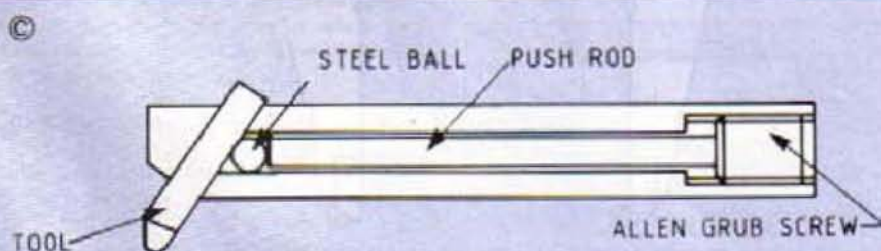
bearing) between the screw and the tool. On the face of it this may not appear to be simple, as one of the original criticisms was the shortage of material available for the screw and to introduce the ball into the screw hole would seem only to aggravate the position. However, the introduction of the ball means that we can now place the pinch screw on the centre line of the boring bar irrespective of the angle of the tool, as the ball will always ensure that the force on the tool will be at right-angles to the tool centre line. This allows us to place the pinch screw at the opposite end of the bar and use a push rod between the screw and the ball.

The complete arrangement is shown in Fig. 3. This configuration has other advantages over the normal fixing as the size of the pinch screw can be considerably increased; in fact the only limiting factor is

tyro. However, in the meantime, Fig. 5 shows a typical flycutter that can be used in either the lathe or the milling machine.

All the cutters referred to in these notes are of circular cross section, which is the type to be recommended as not only is round tool steel stock more readily available than small square sections but it also provides a use for broken centre drills! Circular cutters can be rotated in the holder which is most useful when screwcutting as the tool can be readily set to the required helix angle thus providing adequate clearance at the heel of the cutter. The author usually grinds a reference face on his cutters which provide a datum for gauging angular settings.

If a square section cutter is used, it can be secured in the manner just outlined for a round cutter although, to be pedantic, square cutters should be clamped in two places at right-angles in order to get maximum rigidity. It is not particularly easy to produce a square hole for a cutter in a one-piece boring bar, very careful filing is required and possibly the use of a broaching tool. Square section tool steel is supplied with sharp corners and owing to the impracticability of producing really sharp corners in a square hole (not a desirable feature as sharp internal corners are ideal stress raisers) it is advisable to remove the corners from the tool by lightly grinding. It is a much simpler matter to produce a round hole as this can be done by drilling and then, preferably, reaming; however, whatever the section of cutter used, the fit of the cutter in its hole must not be a sloppy one.



**FIG. 3. TYPICAL ARRANGEMENT OF A BORING BAR USING THE STEEL BALL FIXING METHOD**



Our survey with the first issue of this magazine showed that 90% of readers owned a vernier caliper, no doubt a reflection of the much more reasonable cost of these now compared to times past. So, in this excellent suggestion to increase their usefulness by David Lammass of Bath, there is a nice little project for most of you

# PRECISION MARKING OUT

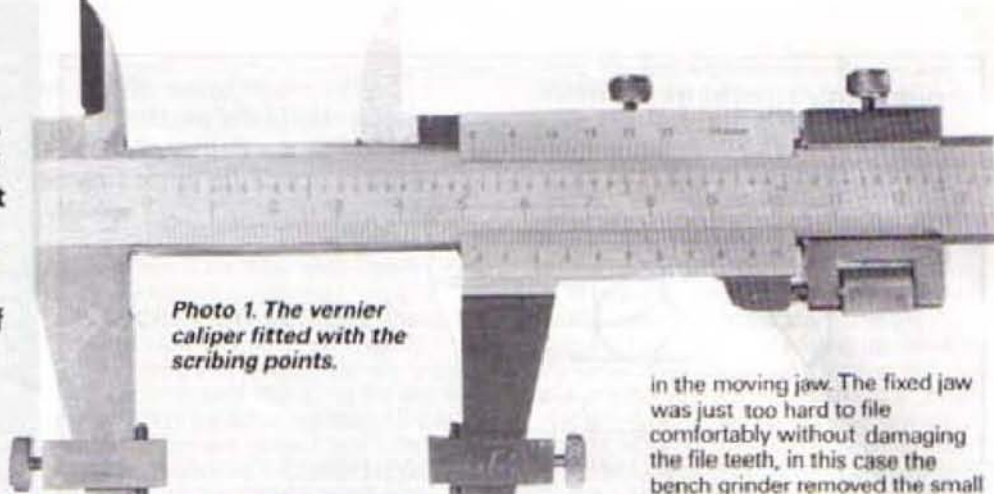
**D**espite your rule possessing thousands of those little divisions marked 64ths or 1/100 inch and your scriber is sharpened to needlelike fineness it is only capable of marking out approximately, good enough for a rough job perhaps although even that assumes your eyesight is not past its prime.

Having devoted a little thought to the problem several simple aids to improved precision have been evolved that are easy to make besides being relatively cheap, the latter being a very rare bird in this affluent(?) technological age. One of these items shown in **Photo 1** will now be described.

It is suspected that most reasonably serious model engineers will already have a vernier caliper for measuring purposes, if you are a newcomer to the hobby with little equipment and not a lot of money to spend, take my advice and get a good one. Don't be tempted to buy a cheap plastic one or a fancy one with a 'clock face' but look for a hardened stainless steel vernier caliper at least 8 inches capacity with Imperial and metric scales, inside and outside jaws, and also fine screw adjustment. I won't mention any names but my photo will show the type to get. Carefully used, such an instrument ought to last a lifetime of model engineering activity.

You may be peeved to read that I am now suggesting a little 'butchering' of your newly purchased pride and joy, however fear not as it is all in a good cause. An instrument that will just measure may be fine for some, I am more demanding so want more for my money therefore an instrument that will both measure and mark out must be better. Ignore those folk who say "you'll spoil its resale value", we are not buying it to resell but to make maximum use of which should enhance its value to the intelligent user rather than diminish it.

The first job is to mark the jaws of the caliper as in **Figure 2** for which a fine pointed felt or fibre tipped pen is best. Although described as hardened stainless steel it is usually only the faces of the jaws that are hard, so I was able to file the step

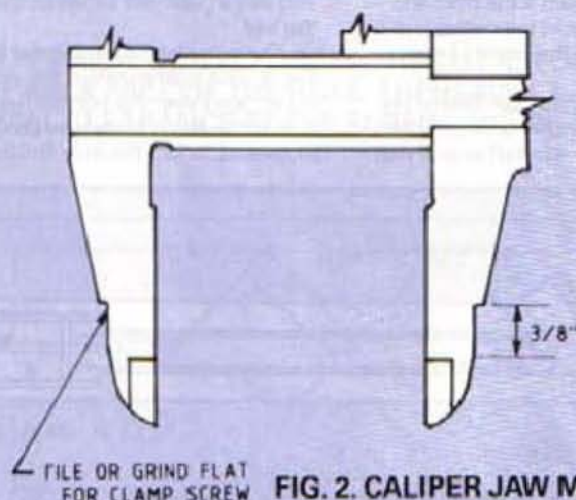
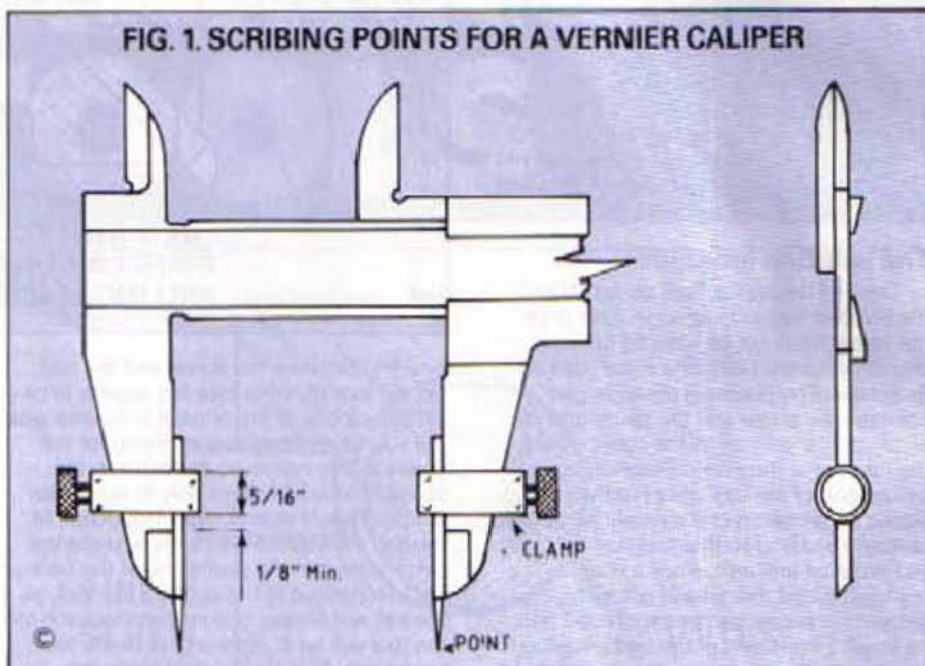


**Photo 1.** The vernier caliper fitted with the scribing points.

in the moving jaw. The fixed jaw was just too hard to file comfortably without damaging the file teeth, in this case the bench grinder removed the small amount of metal.

These flat steps allow the clamping screw seen in **Figure 1** to bear on the jaw, the small brass clamps hold scribing points firmly against the inside faces of the jaws as can be seen in **Photo 2**. What can we do with these points? A few suggestions will show the usefulness of the method: How do you usually scribe a circle on a workpiece? How do you set your dividers accurately? Scribing a precise 6 inch circle

**FIG. 1. SCRIBING POINTS FOR A VERNIER CALIPER**



**FIG. 2. CALIPER JAW MODIFICATION**

- NOTE:-**
- 1) CLAMPS TO BE CLOSE FIT ON JAWS.
  - 2) CLAMPS ASSEMBLED USING SMALL SIZE PAPER CLIP WIRE FOR RIVETS.
  - 3) ROUND POINTS MUST BE STRAIGHT & ACCURATELY POINTED
  - 4) ADD DIAMETER OF ONE POINT TO REQUIRED MEASUREMENT BEFORE USING AS SCRIBER.



is no problem at all with my method. If you need to 'step out' accurate hole positions around a circle it's much simpler than using dividers with the resulting trial and error that never seems to be just right. What about marking out the axle positions on your loco frames? This way you'll get them right first time and KNOW they are in the correct position. Conrod centres plus a multitude of other settings becomes as easy as writing your name and a lot easier than signing a cheque!

Is there a snag in the method? If the round scribing points are used, they must be truly concentric, also you MUST remember to increase the reading on the caliper scale by the exact diameter of one scriber shank. An alternative that eliminates these possible sources of error is to make the scribing points from small square section tool steel, for instance slices cut from a piece of thin gauge plate. These are sharpened to a chisel-edge form of point that is precisely in line with the face of the jaw, therefore the marks made will be

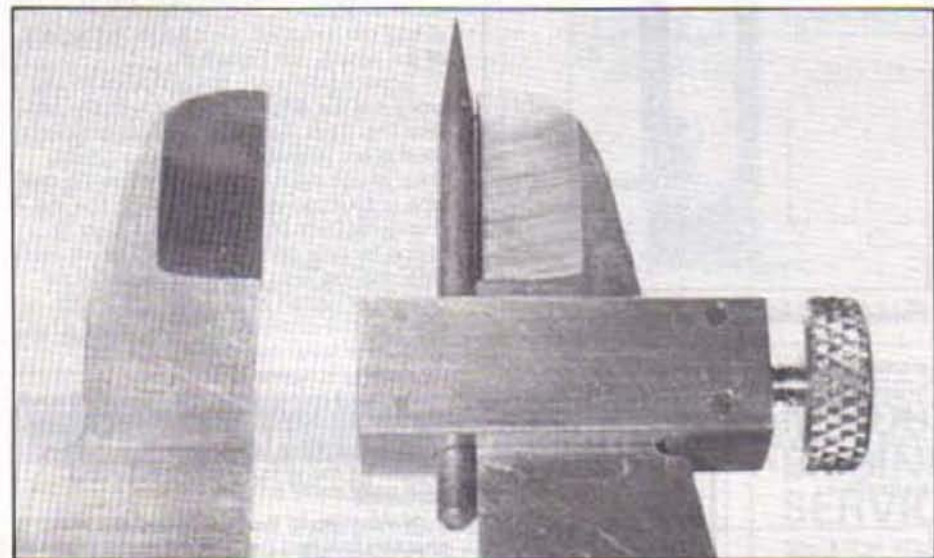
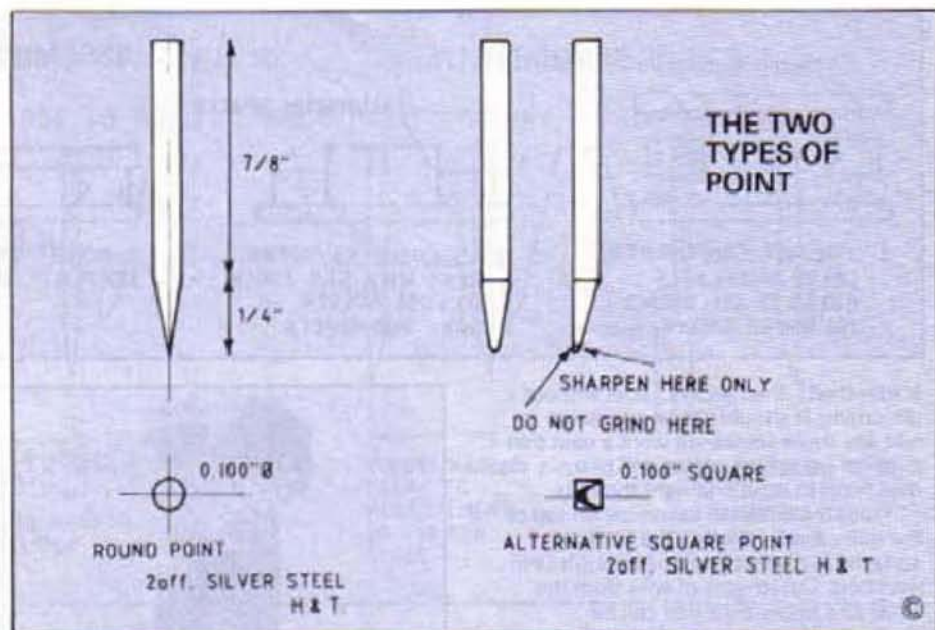
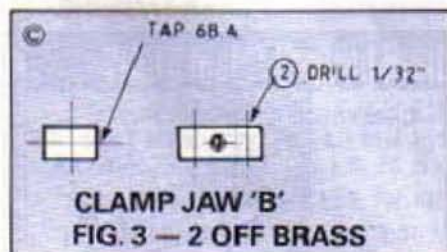


Photo 2. Here we can see the modified jaw on the left, and fitted with point on the right.

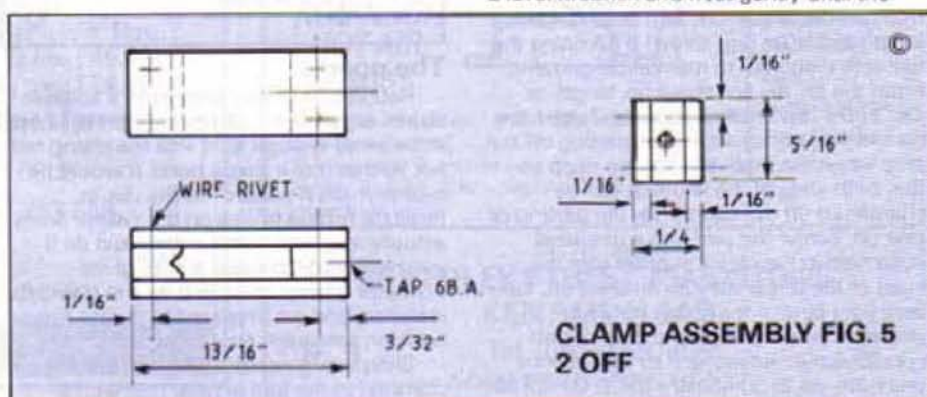
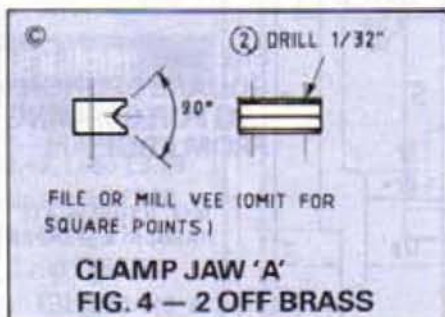


exactly at the distance shown on the scale. These square ones are in fact easier to sharpen than the round ones for which a jig to hold them on the grinder is required, as can be seen in Figure 9.

### Construction

Prepare about a 1 1/2 inch length of 1/16 inch thick by 1/16 inch wide brass strip either by cutting from sheet or as purchased strip. This is sufficient material to make the central parts of the sandwich for both clamps. Cut it in half, mark one piece out for the two clamp screw holes, drill and tap 68A. Cut in half again, it is always easier to handle the pieces if the cutting is left till last.

Mill or file a Vee along one edge of the



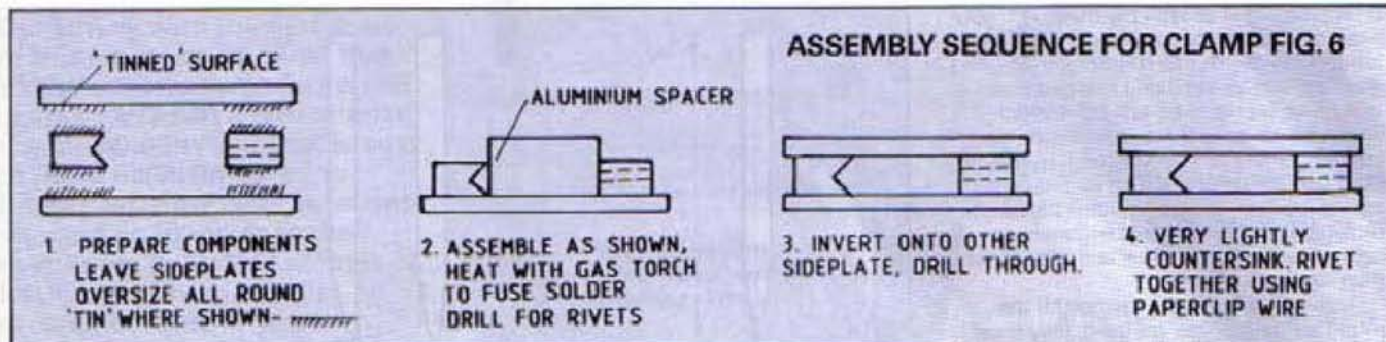
other piece of metal, the filing is assisted if a shallow hacksaw cut is first made along the centre to guide the corner of the file. Use a square file but stop just before the sides of the groove come to a sharp edge, there should be a small flat left at each side. When finishing the Vee it may be found easier to rub the strip along the file instead of the other way round. Grip the file across corners in the vice for this operation so that one corner is uppermost, fit soft jaws to the vice or the teeth will suffer. Again cut this piece in half on completion.

Reference to the drawing, Figure 5 indicates that we have deliberately left the parts too wide and too long, which is done to ease the assembly, the clamps will be filed to size all around later.

A strip of brass 1/16 inch thick by 1/16 inch wide and about 3 1/2 inch long is cut into four equal pieces to make the clamp sides. Figure 6 shows the complete sequence of assembly. 'Tin' the areas marked using soft solder, I use the flux-cored electrical solder sold on a reel, it is about 1/16 inch diameter. Clean the brass with fine abrasive paper, hold one end of the brass with pliers then warm the other end over a small gas flame until it is hot enough to melt the solder touched to it. Lead the molten solder around to cover the area required and immediately, with a quick flick of the wrist, shake off any surplus onto the floor. Do all the areas in similar fashion.

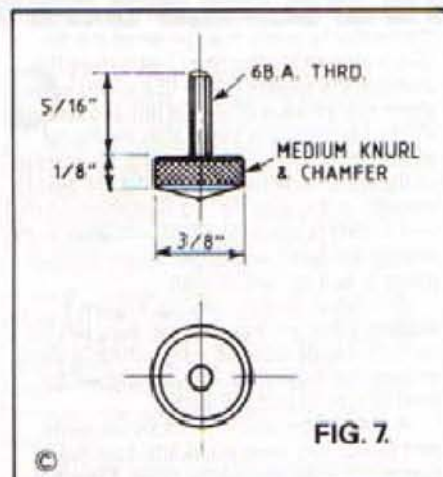
File a small piece of aluminium strip to the same size as the width of the caliper jaw across the step Plus the diameter of the scribing point shank. Use this spacer to position the clamp parts as in the second diagram of Figure 6. Place the assembly on a level firebrick and heat gently until the





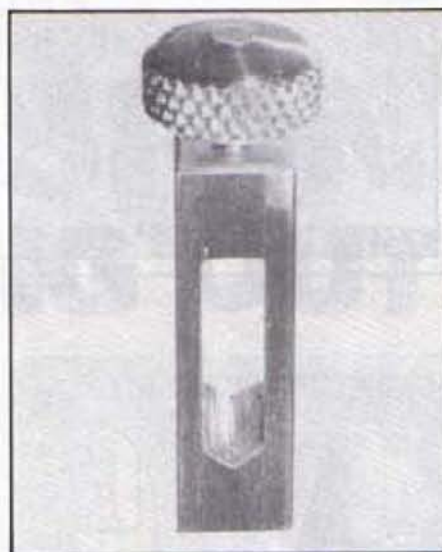
solder melts, then allow to cool without disturbing. It should not be necessary to add any more solder, we want a neat thin joint not great blobs. Now drill two  $\frac{1}{16}$  in. dia. rivet holes in each end right through.

Place the soldered assembly on top of the other side plate with the tinned surfaces in contact and drill through ONE rivet hole. Cut lengths of wire from the small size paper-clips that can be purchased at stationers, place one piece



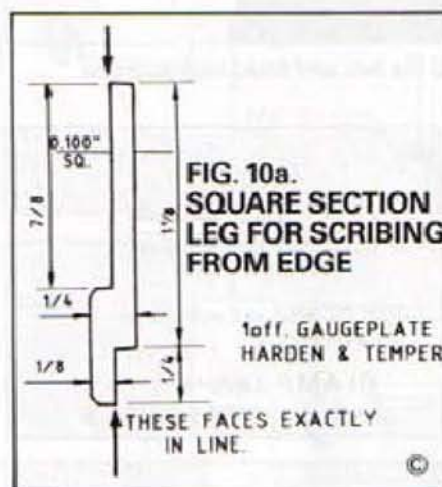
through the hole just drilled. Drill the second hole, stick a wire through then deal with the other two in the same manner. Remove the wires one at a time to slightly countersink each end of the hole with a small drill, replace the wire before doing the next. File each wire to a very small fraction longer than the hole before lightly rivetting it into the countersinks, very little strength is needed so don't overdo things or it will look unsightly. Now gently heat it all again to fuse the solder making a completely rigid fitting. The final job is to file all around to size and take off sharp edges leaving small neat chamfers as can be seen in **Photo 3**.

The clamp screw **Figure 7** is turned from  $\frac{1}{16}$  in. dia. brass rod. Turn down a  $\frac{1}{16}$  in. length to 0.110 in. dia., thread 6 BA using the tailstock dieholder to maintain alignment. Knurl the  $\frac{1}{16}$  in. dia. for about  $\frac{1}{2}$  in. length or just turn a few shallow grooves if you have no knurling equipment. Start parting off but stop when the groove is not too deep so that both ends of the knurling can be chamfered off then complete the parting or saw off. Screw the part into a threaded bush held in the chuck in order that the head of the screw may be finished off, take very light cuts or the screw might be sheared necessitating a fresh start with considerable muttering. If by any chance you have yet to purchase a lathe, do not be



**Photo 3. The finished clamp assembly.**

dismayed, fit a cheese-head or round-head brass screw with a 'butterfly' of thin brass soft soldered into the slot thus making a male butterfly the companion of a butterfly nut. (Wing nut if you are not familiar with butterflies.)



### The points

Round points are made from a suitable size of silver steel rod; obviously it will have to be small enough to fit into the clamp but not so thin that it might bend. It would be nice to make it exactly 0.100 in. dia. to facilitate setting to size on the caliper scale, actually any reasonable size would do if you remember to make a note of the diameter (stamp or write it on the clamp for instance) and are prepared to do the simple addition sum each time it is used.

Sharpening needs a little vee block clamped to the tool grinder rest with a

small collar clamped to the shank for endwise location. The vee block is clamped at half the included point angle to the face of the wheel, see **Figure 9**.

Square points are not critical as to size since it is the edge in contact with the jaw face that does the marking. If square silver steel is not available, cut strips from  $\frac{1}{16}$  in. thick gauge plate and file to fit leaving one side untouched where it contacts the jaw. A triangular form of point is quite easy to shape by only grinding the two facets away from the jaw side, the latter must not be ground or honed at all. Touching up can be done on the oilstone, it is only when a fair amount of wear has taken place that regrinding is needed.

An 'odd-leg' is shown in **Figure 10** and **10a** which facilitates scribing lines parallel to an edge of the workpiece, this too should be made from gaugeplate and hardened.

Hardening of the points and leg after shaping involves heating the component to cherry redness in a gas flame large enough to envelope it completely. A length of thin iron wire should be wound around the item tightly enough to hold it firmly and leaving



sufficient remaining to act as a handle from which it is suspended. When evenly hot all over, the piece should be immediately plunged in a vertical attitude into about a pint of rape-seed oil, move it gently up and down in the oil until cool. Being now very hard but extremely brittle it has to be tempered to restore some toughness. Carefully polish the metal with fine abrasive paper especially towards the point, now slowly warm the shank portion by waving it about above a small gas flame. Soon a



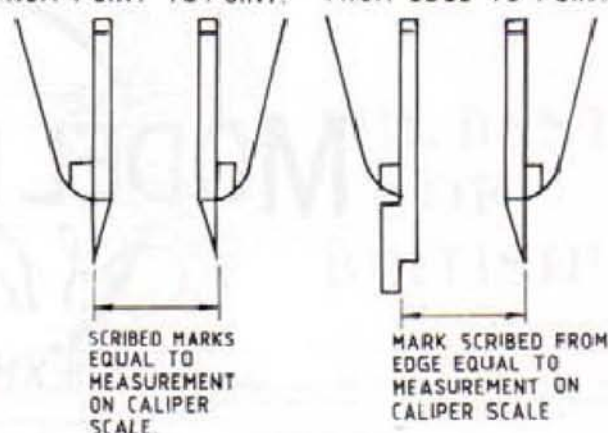
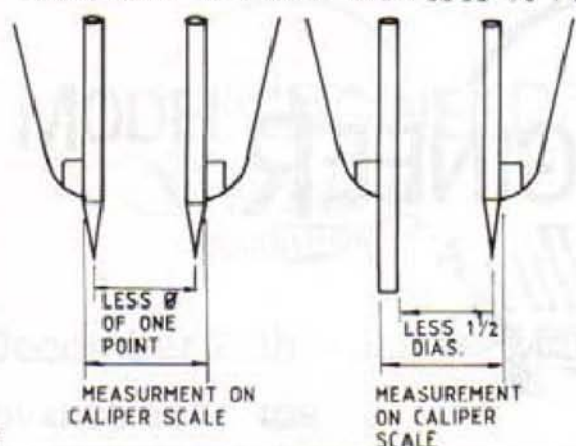
# WITH ROUND POINTS

FIG. 10

# WITH SQUARE POINTS

FROM POINT TO POINT. FROM EDGE TO POINT

FROM POINT TO POINT. FROM EDGE TO POINT



series of coloured bands will appear and travel along the shank to the point, immediately when a light yellowy straw colour reaches the tip, immerse the part in the oil again to halt the temperature rise. Parts tempered to 'straw colour' are hard enough for cutting-tools or scribes.

Figure 11 shows how the modified calipers may be used to mark out a loco frame, many other uses will soon become apparent as experience of the method is gained. Like a number of other techniques, it is not long before one wonders how on earth such jobs were done before the device was made.

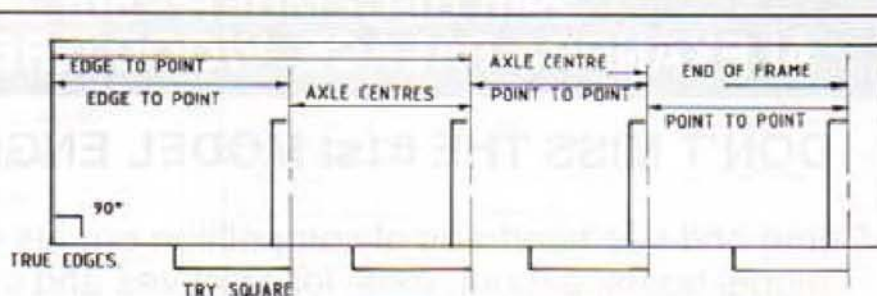


FIG. 11. TYPICAL EXAMPLE — MARKING OUT LOCO FRAME

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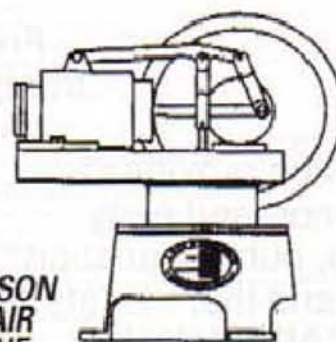
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# NUMBER CRUNCHING FOR THE HOME WORKSHOP

**M**ore and more model engineers have home computers and more and more are realising just what the machine can do for them in their model engineering. There are many facets of home workshop practice that can be improved with the use of a home computer. This is not to say that the home machinist has to rush out and buy one, but if one is available, then why not make use of it? Unfortunately, computers tend to be manufactured in such a way that publishing programs for the model engineers workshop is difficult. If a magazine such as this is to publish programs for running in the home computer then I think that it is essential that some elementary rules are established.

1. The program should be written in BASIC, as that is the language of most home computers. Yes, I know that BASIC is not so much a programming language more a collection of dialects, but even so it is possible to write programs that will run on the majority of machines with little or no translation even though the end result may not be the optimum for your machine or the tidiest of programs.

Some of the instructions will of necessity be machine dependent, such as INPUT, PRINT etc. If there is likely to be confusion, then REM statements should be included explaining what is going on. For example, the first line of all my programs is a REM statement with the name of the program. GET instructions should be avoided, as the keyboard buffer is one of the biggest differences between machines.

2. The program should be submitted as a LISTING from a printer. In this way the program can be published directly as submitted with no possibility of errors in transcription. Please make sure that the printer has a nice black ribbon before printing as dark grey on light grey is not the best of contrasts. If using a dot matrix printer, enhanced or double strike mode will improve the quality of print enormously.

3. A brief description of what the program sets out to do and how the program achieves this. If the author sets this out clearly, firstly to himself, then the program will be better ordered and more easily followed by the reader and potential user.

4. A worked example, with results if possible from the printer. I think this is one of the most important points, as it is the only way a reader can check that his entering of the program is correct. Statements like "the program should run first time" have little meaning when the reader/operator can see quite clearly that it doesn't!

5. The simpler the program the more likely it is that it will be found useful by the readers. If the reader so wishes, niceties such as full data input checking can be added at a later stage.

So what can you use the computer for? I find that I use the computer mostly in one of two categories:

The use of some form of mathematics in the workshop is inevitable. In this article, Dr Mark Phillips describes how the home computer can be used to save some of the work involved and so allow more time for machining operations. The programs are designed to be adaptable to the majority of home computers

LIST

```
10 REM *** FRACTIONS ***
20 REM
30 INPUT "NUMBER = ";N
40 A1 = INT (N)
50 X1 = 1
60 Y1 = N - A1
70 N2 = 1
80 D2 = 0
90 N3 = 0
100 D3 = 1
110 N1 = A1 * N2 + N3
120 D1 = A1 * D2 + D3
130 IF N1 = 0 THEN 180
140 R = N1 / D1
150 PRINT N1;" / ";D1;" = ";R
160 IF ABS (R - N) < 1E - 8 THEN END
170 GOSUB 290
180 A1 = INT (X1 / Y1)
190 X2 = Y1
200 Y2 = X1 - A1 * Y1
210 X1 = X2
220 Y1 = Y2
230 N3 = N2
240 N2 = N1
250 D3 = D2
260 D2 = D1
270 GOTO 110
280 REM PAUSE SUBROUTINE
290 GET A$: REM SPACE
300 IF A$ = " " THEN RETURN
310 GOTO 290
320 END
```

IRUN

```
NUMBER = 3.141592654
3/1 = 3
22/7 = 3.14285714
333/106 = 3.14150944
355/113 = 3.14159292
103993/33102 = 3.14159266
```

IRUN

```
NUMBER = .837520938
1/1 = 1
5/6 = .833333333
31/37 = .837837838
67/80 = .8375
433/517 = .837524178
500/597 = .837520938
```



```

IRUN
NUMBER = .31496063
1/3 = .333333333
5/16 = .3125
6/19 = .315789474
17/54 = .314814815
23/73 = .315068493
40/127 = .31496063

IRUN FACTORS
NUMBER 12
2 2 3

NUMBER 123
3 41

NUMBER 1234
2 617

NUMBER 12345
3 5 823

NUMBER 123456
2 2 2 2 2 2 3 643

NUMBER 1234567
127 9721

NUMBER 12345678
2 3 3 47 14593

NUMBER 123456789
3 3 3607 3803

NUMBER 12345678910
2 2 2 2 2 2 3 7 9185773

NUMBER 0

```

a) as a 'memory' for those useful, but hidden away, bits of information such as calculations for a leaf spring, and  
b) as a means of doing some bits of obscure mathematics where a sequence of operations is required to get the right answer. In the second case, I can always use my calculator, but the chances of pressing the wrong button increase considerably where repetition is concerned and boredom begins to set in.

As an example of the last use, I have written two programs concerned with handling numbers, which I have found useful and I think are of interest to the model engineer. They also follow the rules I gave earlier and I like to think that they are quite good examples of how computer programs should be set out for the model engineer.

### Converting decimals into fractions

It is sometimes desirable to convert a decimal number into a fraction, particularly where gears or indexing are concerned.

There is a way of doing this called 'continuous fractions', which are a bit of a mathematical oddity, and look like:

$$\text{Number} = A_1 + \frac{1}{A_2 + \frac{1}{A_3 + \frac{1}{A_4 + \text{etc}}}}$$

The number is obtained by calculating each fraction using previously calculated values, and each successive fraction calculated is a closer approximation to the number required. These repeating calculations are most easily done using a computer, and the program given was written for the Apple ][e. I have deliberately written the program with only one instruction per line number. If you want to, the program can be shortened by using more than one statement per line number of your machine allows this.

Looking at the program listing, the setting up is done in lines 10-100. N1 and D1 are the numerator and denominator of

the fraction and are calculated in lines 110 and 120 using the two previous values N2 and N3 and D2 and D3 respectively. R is the current value of the fraction and is printed in line 150. If the current value = the input value to the 7th decimal place, the program stops, line 160. The program pauses after this calculation and is restarted by the pause subroutine, lines 290-310; adapt these to suit your machine, or remove them altogether if you so wish. If the program is continued, the values are updated in lines 180-260 and the program returns to line 110 to calculate the next approximation.

To use the program, enter the number and the computer will print successive approximations. The first 'answers' are always a bit silly but after two or three calculations the fraction is getting quite close to the desired value.

As a worked example, I used the value of  $(\pi)$  as the number and got the output shown. It can be seen that after four calculations, the fraction  $\frac{355}{113}$  is a remarkably good approximation and one that is easily remembered if your calculator or computer does not have  $(\pi)$  built in.

Those that are really observant will spot that the fraction  $\frac{355}{113}$  is made up by adding the numerators and the denominators of the two previous fractions thus:

$$\frac{355}{113} = \frac{22+333}{7+106}$$

This useful property can be employed when trying to calculate gear trains for indexing or for the lathe lead screw.

In his book *Gears and Gear Cutting*, (Argus Books £6.95 plus 75p. pb - Ed), Ivan Law takes as a worked example cutting a worm (for use with a 30DP gear wheel) of 0.1047 in. pitch using a  $\frac{1}{16}$  in. pitch lead screw. This requires a fraction of  $\frac{1047}{10000}$  in the gear train and he shows how to calculate the continuous fraction by longhand. I have run the program with this value (0.837520938) and fortunately get the same set of fractions as Ivan did.

However, this continuous fraction method generates a lot of prime numbers as either the numerator or denominator (or both) of the fractions and prime numbers are not easy to build into gear trains using the standard set of change wheels. The prime numbers in the two examples so far are 31, 37, 67, 113, 433 and 103993 but I think we can ignore the last one as a Myford change wheel with that number of teeth would be over 500 feet in diameter!

Additional fractions can be generated by adding the numerators and denominators, as before, with the advantage that adding together two prime numbers gives a number which must factorise. The most useful of these new fractions is:

$$\frac{31+67}{37+80} = \frac{98}{117} = \frac{14 \times 7}{9 \times 13} = \frac{70 \times 70}{90 \times 65} = \frac{35 \times 70}{45 \times 65}$$

### QUICK TIP

When setting up work in the lathe using a dial test indicator, the needle will behave in a far more gentlemanly fashion if the work is lightly lubricated with a smear of fine machine oil, such as 3 in 1. If you do not believe me, just try it and see for yourself!

Joe Ginn



which means that four wheels (35, 45, 65, 70) from a standard set can be used to cut the worm.

As a last example, imagine wanting to cut a thread with 1mm pitch with a normal  $\frac{1}{4}$  in. pitch lead screw. The required gear ratio is  $\frac{1}{4} = 0.31496063$ . 127-tooth wheels are available for some lathes but they are large, over 8 in. in diameter for a Myford. Adding the last two fractions together:

$$\frac{23}{73} + \frac{40}{127} = \frac{63}{200} = \frac{21 \times 30}{40 \times 50}$$

gives a fraction that is usable but needs a special 21-tooth wheel in addition to the standard 30, 40 and 50-tooth wheels.

If you want to cut metric pitches on your imperial lathe, it is not difficult to cut a 21-tooth wheel and it is certainly easier than cutting one with 127 teeth! The 1mm thread wanted will have a pitch of 1.00013 mm, which I suspect is well within the lead screw error of most lathes.

## Factors

In the previous program, I said that 31, 37, 67, 113, 433 and 103993 were prime numbers. This was checked by this program which will calculate and print the factors of any number input provided it is within the capacity of your machine. In the case of the Apple IIe, this is less than 10000000000 which should be good enough for most purposes!

The program inputs the number and then sees if a sequence of prime numbers is a factor of it. If so, then the number is divided by the factor, the factor is printed, and the calculations started again. If the factor tried is greater than the square root of the number, then the number must be a prime number and this is then output.

After the initial small number of primes 1, 2, 3, 5, 7 the prime numbers come as part of a sequence of eight numbers with a repeat factor of 30:

|     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|
| 11  | 13  | 17  | 19  | 23  | 29  | 31  | 37  |
| 41  | 43  | 47  |     | 53  | 59  | 61  | 67  |
| 71  | 73  |     | 79  | 83  | 89  |     | 97  |
| 101 | 103 | 107 | 109 | 113 |     |     | 127 |
| 131 |     | 137 | 139 |     | 149 | 151 | 157 |
|     | 163 | 167 |     | 173 | 179 | 181 |     |
| 191 | 193 | 197 | 199 |     |     | 211 |     |

This sequence excludes all multiples of 2, 3 and 5 and the gaps are the multiples of higher primes 7, 11, 13, etc. Consequently, this sequence of eight numbers will generate all the prime numbers greater than 9 and so can be used to check very quickly for the factors of a number.

Looking at the program listing, the lines 30 - 80 set up the array Z to contain the first four and then the sequence of prime numbers. The number is input and checked for zero to halt the program in line 120. F is

## QUICK TIP

When mixing silver soldering or brazing flux, try using methylated spirit instead of water when making the paste. If kept in a screwtop jar (the individual jam-pots from Little Chef restaurants are perfect), the flux will last well. It seems to wet the job even better if a couple of drops of washing-up liquid are added to the mix.

## LIST

```

10 REM *** FACTORS ***
20 REM
30 DIM Z(12)
40 DATA 2,3,5,7,11,13,17,19,23,29,31,37
50 FOR I = 1 TO 12
60 READ Z(I)
70 NEXT I
80 REM
90 REM *** START CALCULATIONS
100 INPUT "NUMBER ";N
110 N = INT(N)
120 IF N = 0 THEN END
130 REM *** CHECK 2,3,5,7
140 FOR I = 1 TO 4
150 F = Z(I)
160 IF N = 1 THEN 370
170 GOSUB 320
180 IF G = 1 THEN 160
190 NEXT I
200 REM *** CHECK PRIMES
210 J = 10
220 FOR I = 5 TO 12
230 F = J + Z(I)
240 IF F * F > N THEN F = N
250 IF N = 1 THEN 370
260 GOSUB 320
270 IF G = 1 THEN 250
280 NEXT I
290 J = J + 30
300 GOTO 220
310 REM *** SUBROUTINE
320 G = 0: IF N - INT(N / F) * F = 0
THEN G = 1
330 IF G = 0 THEN RETURN
340 PRINT F; " ";
350 N = INT((N + .1) / F)
360 RETURN
370 PRINT
380 PRINT
390 GOTO 100
400 END

```

a possible factor and is successively given the value of 2, 3, 5 and 7 in lines 140 - 190. If the number is 1, all the factors have been found, so exit the calculation (line 160). The subroutine 320 checks to see if F is a factor of the number and returns the flag G, if so. It then prints the factor (line 340) and divides the number by the factor. The somewhat complicated arithmetic is to make sure that there are no rounding errors in the division and that the number N is always integer. This could be a problem if there are many factors in a large number.

If the factor is greater than 7 then all subsequent possible factors are checked, as earlier in the subroutine, in lines 220-300 in groups of 30 starting at 10. Line 240 checks to see if the possible factor is within

range, ie less than the square root of the number. If not, then the number must be prime and the factor is set equal to the number so that the calculations can end.

I used the numbers 12, 123, 1234, etc., to test the program with the results as shown. Entering zero, stops the program. If a number is prime, then only the number is printed. If not, all the factors are output in ascending order. You can see that the program can calculate quite big factors like the prime number 5,882,353 and it is an easy way of checking if a number is prime. If the number is very large, then the program will take some time, so be patient; the number 999,999,938 took about 30 seconds while the prime number 999,999,937 took over 6 minutes!

